1983

Southern Pine Beetle: Annotated Bibliography, 1868-1982

David Kulhavy
Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, dkulhavy@sfasu.edu

Paul C. Johnson
Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University

Southern Pine Beetle:

Annotated Bibliography, 1868-1982

David L. Kulhavy
and
Paul C. Johnson

Center for Applied Studies
School of Forestry
Stephen F. Austin
State University
Nacogdoches, Texas
1983

ABSTRACT

The FAMULUS computerized literature retrieval system was used to produce an annotated bibliography for the southern pine beetle. *Dendroctonus frontalis* Zimmermann. The bibliography contains 1,235 citations and is cross indexed by AUTHOR, TAXONOMY and KEYS to subject areas.

COVER: Photograph provided by Ron Billings, Pest Control Section, Texas Forest Service, Lufkin, Texas

SOUTHERN PINE BEETLE:

ANNOTATED BIBLIOGRAPHY, 1868 - 1982

David L. Kulhavy and Paul C. Johnson

Technical Assistance:

Nathan C. Gold

Sharon J. Seaborn

Steven R. Tracy

Mark N. White

Center for Applied Studies

School of Forestry

Stephen F. Austin State University

Nacogdoches, Texas

1983

This bibliography was typeset via
telecommunications and set in Century Type

Lufkin Printing Company, Inc.

INTRODUCTION

The southern pine beetle (SPB), *Dendroctonus frontalis* Zimmermann (Coleoptera: Scolytidae), originally described by Dr. Charles Zimmermann in 1868 (1232), is the most destructive forest insect pest in the southeastern United States and parts of Mexico and Central America. Several bibliographies and reviews have summarized southern pine beetle activity and literature. A. D. Hopkins in 1899 (479) reported on investigations to determine the cause of unhealthy pines and spruce from 1890-1893 in West Virginia. Osgood (777) prepared a bibliography of the SPB for information through 1955. In 1960, Thatcher (985), reviewed *D. frontalis* literature. In 1972, Coulson *et al.* (251) condensed reports on the southern pine beetle from 1961-1971, including beetle development, natural enemies, behavior, survey and detection and economic aspects. Payne *et al.*, in 1974 (805), edited a symposium incorporating southern pine beetle population dynamics, life history, economic impact and ecological role.

The compendium of the Expanded Southern Pine Beetle Research Applications Program (ESPBRAP), edited by Thatcher *et al.*, 1980 (1001), included summaries of research investigations on *D. frontalis* life history; natural enemies; climate, site and stand factors; population dynamics; sampling; impact guidelines for reducing losses due to *D. frontalis*, and development of integrated pest management strategies. Thatcher and Wilson (1002) published a bibliography of the ESPBRAP including articles, theses and dissertations supported by the program.

The current Integrated Pest Management—Southern Pine Bark Beetles Program (IPM) is implementing the technology developed during the ESPBRAP. One of the objectives of the IPM is to provide a reference library, computerized literature file and annotated bibliography of *D. frontalis*.

The reference library and computerized literature file are maintained at Stephen F. Austin State University. The computerized file, maintained on the Honeywell® CP6 computer, is an interactive, user-friendly system adapted from FAMULUS. FAMULUS, a personal documentation system for indexing and crosslisting reference articles, was developed specifically for cataloging and retrieving citations from the reprint files of research scientists (Burton *et al.* 1971). The version of FAMULUS we used consisted of eight individual computer programs written in FORTRAN. These programs are:

1. **EDIT** The workhorse of FAMULIS, **EDIT** performs the primary data-handling and data-editing chores, including addition and deletion of citations, corrections, and changes in fields labels.
2. **SEARCH** Selects and prints citations using a **SEARCH** request with the following logical operators: OR, AND, and AND NOT.
3. **GALLEY** Prints citations by fields or in a bibliographic format.
4. **SORT** Arranges citations into alphabetical or numerical order by fields or combination of fields.
5. **MERGE** Combines sorted citations in groups.
6. **INDEX** Produces an alphabetical list of words in fields by citation number.
7. **OSSIFY** Produces card images of citations.
8. **VOCAB** Scans any field and compiles an alphabetical list of terms occurring in the field(s). These lists can be used for editing or construction of **SEARCH** formulas.

This annotated bibliography, containing 1,235 articles, was prepared using the FAMULUS System and transmitted via telecommunications to Lufkin, Texas, for printing using a compu**graphic** Editwriter 7770II. Articles for the bibliography were obtained from the IPM program, directly from authors, or through interlibrary loan at Steen Library, SFASU. The computerized FAMULUS System can be used to either 1) store and retrieve citations, or 2) prepare bibliographies for use through publication or other outlets.

Citations entered in this annotated bibliography are abbreviated following BIOSIS guidelines (Anonymous 1982), except United States Department of Agriculture, abbreviated as USDA. Authors are entered as all capitals for ease in computer searching. The order of fields entered from FAMULUS are **AUTH** (author); **YEAR** (date of publication), **TITL** (title of publication), **SOUR** (source of citation), **TAXO** (taxonomy of *D. frontalis* and its major associates), **KEYS** (keywords for indexing by subject), and **ABST** (annotation of each citation). When accessing FAMULUS, these fields may be searched **(SEARCH)** separately or in combination with other fields.

The bibliography contains three Indexes, AUTHOR (**AUTH** field), TAXONOMY (**TAXO** field), and KEYS (**KEYS** or subject field). These indexes can be used to reference articles either in the bibliography or the computerized FAMULUS file maintained at SFASU. Titles of articles are reproduced exactly as found in the original reference; therefore, for example, **Zimmermann**, often spelled as **Zimmerman**, was not changed.

The annotated bibliography is currently maintained and updated using the FAMULUS System at SFASU. Periodic updates will be available upon request.

REFERENCES

Anonymous. 1982. Serial sources for the Biosis Data Base. BioSci. Info. Serv., Philadelphia, Pa. 343 p.

Burton H. D., Russell R. M., Yerke T. B. 1971 (rev.). Famulus: A computer-based system for augmenting personal documentation efforts. USDA For. Serv. Pacific Southwest For. and Range Exp. Stn. Res. Note PSW-193. 40 p.

1. **ALCOCK J.** 1982. Natural selection and communication among bark beetles. Fla. Entomol. 65:17-32. (COLEOPTERA: SCOLYTIDAE). REVIEW, BEHAVIORAL CHEMICALS Chemical communication in bark beetles is reviewed.

2. **ALDRICH R. C., HELLER R. C., BAILEY W. F.** 1958. Observation limits for aerial sketch-mapping southern pine beetle damage in the Southern Appalachians. J. For. 56:200-202. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Aerial sketch mapping technique and accuracy are discussed along with checks on the consistency of several observers. No difference was found in observer accuracy. A significant difference was found in strip width. Recommendations for improvement are made.

3. **ALEXANDER S. A.** 1977. Severity of *Fomes annosus* infected root systems in southern pine beetle infested loblolly pine plantations. Ann. Proc. Am. Phytopath. Soc. (Abst) 4:120. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Heterobasidion annosum*). PATHOGENS, MISCELLANEOUS TECHNIQUES A significant association between *Fomes annosus* and southern pine beetle infestations was found.

4. **ALEXANDER S. A., SKELLY J. M., WEBB R. S.** 1978. Disease incidence and severity of *Heterobasidion annosum* in southern pine beetle attacked and nonattacked plots. Phytopathol. News 12:75. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Heterobasidion annosum*). PATHOGENS Southern pine beetle is associated with *H. annosum*.

5. **ALEXANDER S. A., SKELLY J. M., WEBB R. S.** 1981. Effects of *Heterobasidion annosum* on radial growth in southern pine beetle-infested loblolly pine. Phytopathology 71:479-481. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Heterobasidion annosum*). HOST RESISTANCE, STAND CONDITIONS, PATHOGENS The interrelationship between *H. annosum*, loblolly pine, and southern pine beetle is discussed. The need for an integrated pest management system approach to dealing with the relationship is recommended. *H. annosum*-stressed trees are important factors in southern pine beetle spot proliferation in plantations. In natural stands affected trees play a much reduced role in southern pine beetle infestations.

6. **ALEXANDER S. A., SKELLY J. M., WEBB R. S., BARDINELLI T. R., BRADFORD B.** 1980. Association of *Heterobasidion annosum* and the southern pine beetle on loblolly pine. Phytopathology 70:510-513. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Heterobasidion annosum*). COMMENSALISM AND SYMBIOSIS, PATHOGENS, SURVEY AND DETECTION Sites infested with southern pine beetle for less than eight weeks were selected for plot establishment. The average incidences of *Heterobasidion annosum* were established for nine southern pine beetle plots and nine control plots. A significant and consistent association between southern pine beetle infestations and the severity of *H. annosum* was found on sandy Coastal Plain soils.

7. **ANDERSON D. A.** 1949. Southern pine bark beetles. Tex. For. Serv. A&M Coll. Bull. 33. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL A layman's guide to recognizing, detecting, and controlling the southern pine beetle. A general review of the biology and life history of the insect is presented.

8. **ANDERSON N. H.** 1964. Improved hydrostatic pressure gauge methods for measuring oleoresin exudation pressure in bark beetle research. Can. Entomol. 96:1322-1327. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MISCELLANEOUS TECHNIQUES, HOST RESISTANCE Two methods for measuring pine oleoresin exudation pressure are discussed. Method one involves a technique for measuring oleoresin exudation pressure from a 1.5 - 2 inch hole bored into the sapwood of the tree. Method two involves a technique for measuring oleoresin exudation pressure at the innerbark-wood interface. Advantages and limitations of both methods are reviewed.

9. **ANDERSON N. H.** 1967. An evaluation of certain methods used for controlling the southern pine beetle: Complete vs. partial spraying of infested logs. Dep. Entomol., Dep. Tech. Rep. No. 4, Tex. A&M Univ. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL The effectiveness of felling and bucking southern pine beetle infested trees, spraying them with a 0.5% gamma isomer of BHC in #2 diesel fuel, and rolling the logs for complete chemical coverage against the same procedure without rolling the logs, was compared. Trees in the peripheries were studied to determine the effectiveness of the two procedures. It was determined that complete chemical coverage is necessary for adequate control.

10. **ANDERSON N. H., BREMER J. E.** 1967. An efficient laboratory technique for obtaining pine bark beetle eggs and young larvae. Fla. Entomol. 50(1):71-73. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, MISCELLANEOUS TECHNIQUES An efficient method for collecting bark beetle eggs and young larvae is described. This method eliminates the dissection of host material and therefore minimizes injuries and destruction of eggs and larvae. A technique is described which allows the bark to be removed intact at the time of egg collection.

11. **ANDERSON R. F.** 1961. The 10 most important forest pests in the south. For. Farmer 21(1):10-11,30-31. (COLEOPTERA: SCOLYTIDAE, *Dendroctonus frontalis*). SURVEY AND DETECTION The southern pine beetle is included as an important forest pest in the southeastern United States.

12. **ANDERSON R. F.** 1966. The growing insect menace. For. Farmer Manu. Ed. 25(7):74-79. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Dendroctonus valens, Ips avulsus, Ips calligraphus, Ips grandicollis*). CONTROL-GENERAL A general discussion of southern forest insect pests is presented with general controls for each. A key to southern forest insects is included.

13. **ANDERSON R. F.** 1971. The practicality of using attractants for control of bark-beetles. For. Farmer 30(7):87-88. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS, CONTROL-BIOLOGICAL Attractants are discussed to manipulate or manage southern pine beetle populations.

14. **ANDERSON R. F., DOGGETT C. A.** 1980. Some relationships between infestations by the southern pine beetle (*Dendroctonus frontalis*) and stand conditions. N. C. For. Serv. Div. For. Res. Note No. 49. 16 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, LIGHTNING Southern pine beetle infestations in North Carolina from 1973 to 1975 were concentrated in dense stands, over 75 percent pine, and 30 to 40 year-old shortleaf pine stands.

15. **ANDERSON R. L., BARRY P. J.** 1978. Southern Region (R-8). USDA For. Serv. For. Insect and Dis. Conditions in the U.S. 1978, GRT-WO-19. p. 43-44. (COLEOPTERA: SCOLYTIDAE; *Dendronoctonus frontalis*). SURVEY AND DETECTION Southern pine beetle populations decreased dramatically southwide in 1978.

16. **ANDERSON R. L., BELANGER R. P., HOFFARD W. H., MISTRETTA P., UHLER R. J.** 1982. Integrated pest management decision key: A decision-making tool for foresters. *In*, Increasing Forest Productivity. Proc. 1981 Soc. Am. For. Natl. Meet., Orlando, Fla. p. 189-193. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Heterobasidion annosum. Phytophthora cinnamomi. Cronartium fusiforme*). INTEGRATED PEST MANAGEMENT, TECHNOLOGY TRANSFER A decision key that is user interactive is presented for management of southern pine beetle, fusiform rust, annosus root rot and littleleaf disease based on stand type and stand condition.

17. **ANDERSON R., MISTRETTA P., EARLE E., FISHER V., GHENT J., HOFFARD W., JOHNSON K., LEE M., MILLER R., STEIN K., WARLICK L.** 1980. Forest insect and disease handbook. USDA For. Serv. Southeast. Area Gen. Rep. SA-GR 14. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips calligraphus, Ips avulsus, Ips grandicollis*). SURVEY AND

DETECTION Characteristics of southern pine beetle attacks are illustrated in color photographs.

18. **ANDERSON W. W., BERISFORD C. W., KIMMICH R. H.,** 1979. Genetic differences among five populations of the southern pine beetle. Ann. Entomol. Soc. Am. 72:323-237. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MISCELLANEOUS TECHNIQUES, GENETICS In five separate populations of *Dendroctonus frontalis* six genes were studied. In some populations, differences were found between the males and females at both the GOT and PGI loci. Evidence supports the idea that the Mexican and Arizonan populations have split from the main body.

19. **ANONYMOUS.** 1892. October 6, 1892. Proc. Entomol. Soc. Wash. 2(3):353-354. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus formicarius*). PREDATOR A. D. Hopkins presents a paper on the introduced clerid, *Clerus formicarius*, as a predator of *Dendroctonus frontalis*. His concensus is that the clerid would replace native clerids.

20. **ANONYMOUS.** 1893. Parasitic and predaceous insects in applied entomology. USDA Div. of Entomol. Insect Life 6:138-141. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus formicarius*). PREDATOR, ECOLOGICAL DISTRIBUTION, CONTROL-BIOLOGICAL A discussion on the attempt to establish the imported scolytid *Clerus formicarius* as a predator of the southern pine beetle is presented. The author also discusses the hazards of introducing imported species of insects and pathogens into America.

21. **ANONYMOUS.** 1913. Report of the Secretary. USDA Yearb. 1912. p. 76-77, 148-149. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, CONTROL-LEGAL, SURVEY AND DETECTION The southern pine beetle was checked through cutting and burning.

22. **ANONYMOUS.** 1919. Southern pine beetle timber menace. Am. Lumberman 2299:43. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, SURVEY AND DETECTION Reports on southern pine beetle damage in 1916 in West Virginia. Mentions A. D. Hopkins' work with cultural control of the southern pine beetle.

23. **ANONYMOUS.** 1923. Protection of forest lands. USDA Yearb. 1922. p. 161-163. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus brevicomis, Dendroctonus ponderosae*). SURVEY AND DETECTION, MAPS General insect conditions in the United States.

24. **ANONYMOUS.** 1924a. Beetle working damage to yellow pine in South. Natl. Lumberman 73:10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Describes 1921 outbreak of the southern pine beetle; weather is one of the best controlling agents.

25. **ANONYMOUS.** 1924b. Dry weather aids beetle. South. Lumberman 116(1508):40. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Dry weather assisted outbreaks of the southern pine beetle.

26. **ANONYMOUS.** 1927. The relation of insects to slash disposal. USDA Dep. Circ. 411. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips calligraphus, Ips avulsus, Ips grandicollis*). IMPACT Southern pine beetles were not a problem in slash.

27. **ANONYMOUS.** 1929. Tiny beetle has destroyed $50,000,000 worth pine timber. South. Lumber J. 33(17):37. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, SURVEY AND DETECTION Briefly summarizes southern pine beetle outbreaks and control measures.

28. **ANONYMOUS.** 1930a. Current notes. J. Econ. Entomol. 23:478. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, WEATHER RELATIONSHIPS An outbreak of southern pine beetle was reported in eastern Tennessee in 1929. Low temperatures in November killed most of the brood in the outer bark.

29. **ANONYMOUS.** 1930b. Use dead trees for fuel to prevent pine beetle. Weekly News Notes. Clemson Agric. Coll. and USDA Coop. 19(23):1 (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Timber with beetles should be harvested to prevent spread.

30. **ANONYMOUS.** 1932a. Beetles in Carolina. South. Lumberman 145(1833):21. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp.). SURVEY AND DETECTION Southern pine beetles are expanding due to lack of rain.

31. **ANONYMOUS.** 1932b. Pine beetle in Louisiana. South. Lumberman 145(1833):21. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Guidelines for examining dead or dying pines for southern pine beetles are given.

32. **ANONYMOUS.** 1933. Analysis of special jobs in farm forestry. Fed. Board for Voc. Ed., Wash. D.C. pp. 29-32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT Southern pine beetle causes losses in woodlot production.

33. **ANONYMOUS.** 1939. Job XI.-Controlling the southern pine beetle. U. S. Div. Vocational Educ. Vocational Div. Bull. No. 196. p. 45-48. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL Life history and control of southern pine beetles are presented.

34. **ANONYMOUS.** 1943. Controlling pine beetles. Clemson Agric. Coll. Circ. No. 240, Clemson, S. C. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CULTURAL Brief summary of life history and direct control for the southern pine beetle.

35. **ANONYMOUS.** 1950a. Southern pine beetles do serious damage in Texas. Naval Stores Rev. 60:30 (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT Reports on the southern pine beetle outbreak in Texas.

36. **ANONYMOUS.** 1950b. Virginia forests as they relate to the Virginia economy. Va. Advis. Counc. on Va. Econ. Comm. For. p. 23-26. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL Southern pine beetle outbreaks are briefly reviewed for Virginia.

37. **ANONYMOUS.** 1950c. Around the states. For. Farmer 10(1):13. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Summarizes southwide southern pine beetle outbreaks for 1950.

38. **ANONYMOUS.** 1950d. Serious threat to timber. Gulf Coast Lumberman 38(16):4. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Describes the southern pine beetle's threat to timber in East Texas.

39. **ANONYMOUS.** 1951a. Insects commonly attacking forest trees and unseasoned timber in the southern states. For. Farmer Manu. Ed., Second Ed. p. 38-41. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Dendroctonus valens, Ips avulsus, Ips calligraphus, Ips grandicollis*). SURVEY AND DETECTION, CONTROL-GENERAL, CONTROL-CHEMICAL A discussion of forest insect detection and control is presented. A key to insects of southern forests is included.

40. **ANONYMOUS.** 1951b. Losses caused by the southern pine beetle in Texas during 1950. For. Farmer 11:11 (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT The southern pine beetle caused major losses in East Texas.

41. **ANONYMOUS.** 1951c. Texas continues to suffer from bark beetle epidemic. Naval Stores Rev. 61:2. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT Southern pine beetle continued to be a problem in East Texas.

42. **ANONYMOUS.** 1954. Fighting the pine beetle. South. Lumberman 188(2347):28. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL Controls for bark beetles, including chemicals and cultured methods, are

summarized.

43. **ANONYMOUS.** 1958. A status report on forest insect conditions in the United States in 1957. FAO Plant Prot. Bull. 6:138-139. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Population levels of southern pine beetle decreased somewhat in 1957, with most of the heaviest activity in western North Carolina, eastern Tennessee, northeastern Georgia, and northwestern South Carolina.

44. **ANONYMOUS.** 1964. Pine beetle research moves up. Boyce Thompson Institute for Plant Research teams up with the southern forest research institute in Texas program. New laboratory dedicated. For. Farmer 23(11):9,16-18. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW Research on the southern pine beetle is summarized.

45. **ANONYMOUS.** 1965. Beetle outbreaks. For. Farmer 24(13):10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION An appraisal of the southern pine beetle situation is presented state by state in the southern region.

46. **ANONYMOUS.** 1968a. Are woodpeckers the answer to pine bark beetle attacks? For. Farmer 28(1):16,26. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, VERTEBRATES The impact of woodpeckers on southern pine beetle populations is discussed.

47. **ANONYMOUS.** 1968b. Bark beetle pheromones. World Rev. Pest Control 7:124. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus ponderosae, Dendroctonus brevicomis, Ips* spp.). REVIEW, BEHAVIOR, BEHAVIORAL CHEMICALS Differences in the way pheromones work to produce responses were observed. In *Ips* attractants are produced during feeding as a means of locating and occupying temporary habitats. In *Dendroctonus*, pheromones are perceived to bring on a mass attack on a resistant host. Pheromones were exuded only as long as the host resists. Also, a sex attractant of *D. brevicomis* was reported in California. The attractant which is produced by the females is exo-7-ethyl-5-methyl-6,8-dioxabicyclo(3.2.1.)octane, trivially called brevicomin.

48. **ANONYMOUS.** 1968c. Can the beetle be beaten? For. and People 18(3):30-33,40. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, SURVEY AND DETECTION, LIFE HISTORY-GENERAL Reviews the life history and cultural controls for the southern pine beetle.

49. **ANONYMOUS.** [1968d]. Southern forest research institute. South. For. Res. Inst., Jasper, Tex. 21 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Pityophthorus annectens, Xyleborus* sp. PLATYPODIDAE; *Platypus* sp. CERAMBYCIDAE; *Monochamus* sp.). REVIEW, SEASONAL OCCURRENCE, BEHAVIORAL CHEMICALS, AGGREGATION The progress of the Boyce Thompson Institute for Plant Research is reviewed for 1963-1967. Distribution maps for the southern pine beetle in East Texas from 1967-1968 are reviewed. The research program included isolation and identification of attractants, aggregation behavior of the SPB, control methods, manipulation of southern pine beetle populations and susceptibility of southern pines to beetle attack.

50. **ANONYMOUS.** 1971. New compound says 'no' to southern pine beetles. For. Farmer 31(2):33. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). AGGREGATION, SEX-RATIOS, ATTRACTANTS, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL Characteristics and usage of *endo*-brevicomin for control of southern pine beetle are discussed.

51. **ANONYMOUS.** 1975a. Programs stepped up in...southern pine beetle research. For. Farmer 34(10):10,22. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, INTEGRATED PEST MANAGEMENT Reviews grants to southern states under the five year accelerated southern pine beetle program directed by R. C. Thatcher. Gives state-by-state southern pine beetle outbreaks.

52. **ANONYMOUS.** 1975b. The southern pine beetle: A native forest pest. *In*, Pest Control: An assessment of present and alternative technology 4:120-127. Natl. Acad. Sci., Wash., D.C. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, ECOLOGICAL DISTRIBUTION, DISTRIBUTION, CONTROL-GENERAL The life history, ecological effects, and various control tactics for *Dendroctonus frontalis* are described and discussed.

53. **ANONYMOUS.** 1977. How to beat the beetle. S. C. State Comm. For. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL A layman's pocket guide to the southern pine beetle. Topics covered include identification, recognition of damage, high risk trees, silvicultural practices, and prevention of logging damage.

54. **ANONYMOUS.** 1980. Pine beetle is epidemic in areas of the South. For. Farmer 39(8):9. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Areas of expanding beetle populations are mapped out for the southern United States for 1979. Areas of expanding populations include Alabama, Georgia, North Carolina, Mississippi, and South Carolina.

55. **ATKINSON T. H.** 1976. Sampling populations of the southern pine beetle, *Dendroctonus frontalis* Zimmerman, for pathogenic microorganisms and nematodes. M.S. Thesis, Univ. Fla., Gainesville, Fla. 77 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Contortylenchus brevicomi, Parasitorhabditis* sp., *Nosema* sp.). PATHOGENS, ATTRACTANTS, TRAPS AND CAGES, MISCELLANEOUS TECHNIQUES, PARASITES, NEMATODES Southern pine beetle populations were sampled for infection by two parasitic nematodes and one microsporidan. Between-tree and within-tree variations in infection rates were not significant. Twelve Coleopteran associates of *Dendroctonus frontalis* were examined for infection; none were found to be important hosts, and their potential role as reservoirs for the pathogens is minimal.

56. **ATKINSON T. H., WILKINSON R. C.** 1979. Microsporidan and nematode incidence in live-trapped and reared southern pine beetle adults. Fla. Entomol. 62:169-175. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Unikaryon minutum; Contortylenchus brevicomi*). PREDATOR, PARASITES, PATHOGENS, TRAPS AND CAGES, NEMATODES A baited live-trap was used to estimate the natural incidence of the microsporidan, *Unikaryon minutum*, and the nematode *C. brevicomi*. Trapped southern pine beetle males and females showed no significant difference in the incidence of *U. minutun*, but *C. brevicomi* incidence was lower in trapped males.

57. **BAKER R. S.** 1977. Effects of cut-top and cut-leave control treatments upon within-tree populations of southern pine beetle (Coleoptera: Scolytidae) and its predators and parasites in loblolly pine. M.S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 98 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*; CLERIDAE; *Thanasimus dubius*). PREDATOR, CONTROL-CULTURAL, PARASITES Neither cut-and-top nor cut-and-leave treatments reduced southern pine beetle emergence significantly in either season compared to check trees. More predators and parasites emerged from cut-and-top and cut-and-leave treated trees than from check trees during the summer but not in the winter. Cut-and-top produced a greater emergence ratio value over both cut-and-leave and check trees during summer. *Thanasimus dubius* exhibited the highest average percentage emergence ratio of all the beneficial species. Greater parasite and predator abundance occurred at 75% tree height.

58. **BAKER W. L.** 1972. Eastern forest insects. USDA For. Serv. Misc. Publ. No. 1175. 642 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips calligraphus, Ips grandicollis, Ips avulsus*. CEREAMBYCIDAE; *Monochamus titillator*). SURVEY AND DETECTION, LIFE HISTORY-GENERAL The life history and identification of the southern pine beetle are outlined.

59. **BALCH R. E.** 1928. The influence of southern pine beetle on forest composition in western North Carolina. M. S. Thesis,

Syracuse Univ., Syracuse, N. Y. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, LIFE HISTORY-GENERAL The southern pine beetle occurs in overdense stands of pines. The beetle will increase in numbers in these stands and reduce pine stocking.

60. **BARKER W. J., NETTLES W. C.** 1954. Controlling pine beetles in South Carolina woodlands. Clemson Agric. Coll. Circ. 239. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, CONTROL-GENERAL BHC is a recommended control for the southern pine beetle.

61. **BARRAS S. J.** 1967. Thoracic mycangium of *Dendroctonus frontalis* (Coleoptera: Scolytidae) is synonymous with a secondary female character. Ann. Entomol. Soc. Am. 60:486. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MORPHOLOGY AND PHYSIOLOGY This paper discusses several morphological features of *Dendroctonus frontalis*. The female possesses a transverse ridge across the anterior area of the pronotum. This ridge represents the external evidence of a mycangium, a fungus repository organ.

62. **BARRAS S. J.** 1969. *Penicillium implicatum* antagonistic to *Ceratocystis minor* and *C. ips*. Phytopathology 59:520. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus terebrans, Dendroctonus frontalis. Ceratocystis minor, Ceratocystis ips, Penicillium implicatum*). COMMENSALISM AND SYMBIOSIS Little is known of the interactions between *Penicillium* spp. and other fungi associated with bark beetles. Petri dish trials have shown that there is a significant antagonistic reaction between *P. implicatum* and both *C. minor* and *C. ips*.

63. **BARRAS S. J.** 1970. Antagonism between *Dendroctonus frontalis* and the fungus *Ceratocystis minor*. Ann. Entomol. Soc. Am. 63:1187-1190. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Ceratocystis minor*). VECTOR, COMMENSALISM AND SYMBIOSIS, REARING The blue-staining fungus *Ceratocystis minor* when acting alone is detrimental to southern pine beetle development. However, the growth of the fungus is inhibited in the phloem when it is present with the beetle and other associated microorganisms.

64. **BARRAS S. J.** 1972. Improved White's solution for surface sterilization of pupae of *Dendroctonus frontalis*. J. Econ. Entomol. 65:1504. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PUPAE, REARING, MISCELLANEOUS TECHNIQUES The rearing of certain insects on artificial diets requires the elimination of ectodermal microbes. Antimicrobial agents are of little use because they often kill many insects. A technique is described which increases the survival of southern pine beetles through surface sterilization of pupae.

65. **BARRAS S. J.** 1973. Reduction of progeny and development in the southern pine beetle following removal of symbiotic fungi. Can. Entomol. 105:1295-1299. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LARVAE, LIFE HISTORY-GENERAL, OVIPOSITION, FECUNDITY, VECTOR, ECOLOGICAL DISTRIBUTION, EMERGENCE, REARING, COMMENSALISM AND SYMBIOSIS Absence of mycangial and ectodermal fungi in loblolly pine bolts caused a decrease in the number of progeny of *Dendroctonus frontalis*. Absence of fungi had no effect on number of attacks, gallery length, and number of egg niches; however, initial emergence of progeny was delayed 13 to 24 days.

66. **BARRAS S. J.** 1975. Release of fungi from mycangia of southern pine beetles observed under a scanning electron microscope. Z. Angew. Entomol. 79:173-176. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). VECTOR, MORPHOLOGY AND PHYSIOLOGY The prosternum of *Dendroctonus frontalis* is possibly a release site for mycangial fungi. Another possible site is behind the edge of the presternum where the opening of the mycangium wall is widest. Several fungi and yeasts previously isolated from the mycangia were found at the release sites.

67. **BARRAS S. J., HODGES J. D.** 1969. Carbohydrates of inner bark of *Pinus taeda* as affected by *Dendroctonus frontalis* and associated microorganisms. Can. Entomol. 101:489-493. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Ceratocystis minor*). MISCELLANEOUS TECHNIQUES, MORPHOLOGY AND PHYSIOLOGY, COMMENSALISM AND SYMBIOSIS Glucose, fructose, and sucrose were detected in inner bark treated with a southern pine beetle-microorganism complex and two beetle-associated fungi. The treatment lowered the reducing sugar level.

68. **BARRAS S. J., HODGES J. D.** 1974. Weight, moisture, and lipid changes during life cycle of the southern pine beetle. USDA For. Serv. Res. Note SO-178. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, MORPHOLOGY AND PHYSIOLOGY Changes in weight, moisture, and gross lipid of *Dendroctonus frontalis* were examined at six developmental stages. The study was one of a series on the nutritional relationships between the southern pine beetle, its associated mycangial fungi, and loblolly pine phloem.

69. **BARRAS S. J., PERRY T.** 1972. Fungal symbionts in the prothoracic mycangium of *Dendroctonus frontalis* (Coleopt.: Scolytidae). Z. Angew. Entomol. 71:95-104. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Sporothrix* sp., *Ceratocystis minor, Penicillium* spp.). ADULT, VECTOR, ECOLOGICAL DISTRIBUTION, MISCELLANEOUS TECHNIQUES, COMMENSALISM AND SYMBIOSIS The predominant fungi observed in the prothoracic mycangium of *Dendroctonus frontalis* were an undescribed *Sporothrix* and a basidiomycete. These were the predominant organisms found in the mycangia of attacking females. Other organisms such as *C. minor* and *Penicillium* spp. and yeasts occur during early adult life.

70. **BARRAS S. J., PERRY T. J.** 1975. Interrelationships among microorganisms, bark or ambrosia beetles, and woody host tissue: An annotated bibliography, 1965-1974. USDA For. Serv. Gen. Tech. Rep. SO-10. 34 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW, COMMENSALISM AND SYMBIOSIS The interrelationships of insects, microorganisms, and host trees are the least under stood of the many factors that influence the development of scolytids within woody hosts. The symbiotic interactions of insects and microoganisms as well as the woody tissue-microorganism associations often influence insect development and survival. This bibliography is a compilation of articles and abstracts concerned with biological, ecological, and physiological parameters of symbiotic associations.

71. **BARRAS S. J., TAYLOR J. J.** 1973. Varietal *Ceratocystis minor* identified from mycangium of *Dendroctonus frontalis*. Mycopathol. Mycol. Appl. 50:293-305. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Ceratocystis minor*). LARVAE, VECTOR, REARING, MISCELLANEOUS TECHNIQUES, COMMENSALISM AND SYMBIOSIS A fungus (SJB 133) was observed reproducing amerosporous cells in the mycangium of the adult female southern pine beetle. In larval galleries it reproduced anascigerously and appeared to be stimulated by the presence of beetle larvae. Studies conclude that the mycangial fungus is a variety of *Ceratocystis minor*. A detailed description of the fungus is presented.

72. **BARRON E. H.** 1970. Deterioration of trees killed by southern pine beetles. M. For. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 58 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PATHOGENS, WOOD UTILIZATION Describes southern pine beetle-killed pines from initial infestation to six months. Blue-stain fungi had penetrated the logs by four months in the summer and six months in the winter. Termites were present in three months. Moisture loss occurred during the first month (decreased 40%), as did weight (decreased 30%); specific gravity continued to decrease through six months (decreased 10%). Pathogens infesting the trees are listed.

73. **BARRON E. H.** 1971. Deterioration of southern pine beetle-killed trees. For. Prod. J. 21:57-59. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMMENSALISM AND SYMBIOSIS, ECONOMICS, IMPACT, WOOD UTILIZATION Regression equations were developed from measurements of specific gravity and moisture content of trees

killed by the southern pine beetle. Felling trees soon after attack reduced moisture loss, but doubled wood substance loss.

74. **BARRY P. J., TERRY J. R.** 1972. Current status of the southern pine beetle in the southeast. South. Lumberman (10-15-72). (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT The southern pine beetle increased in the south in 1972.

75. **BEAL J. A.** 1927. Weather as a factor in southern pine beetle control. J. For. 25:741-742. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, WEATHER RELATIONSHIPS Epidemics of the southern pine beetle are often characterized by their rapid rise and subsequent disappearance. This rapid disappearance has in part been attributed to excessive rainfall and low winter temperatures. The stages, conditions, and mortality of beetle broods are correlated to weather conditions occurring in North Carolina during the winter of 1926-27.

76. **BEAL J. A.** 1933. Temperature extremes as a factor in the ecology of the southern pine beetle. J. For. 31:329-336. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Southern pine beetle populations are to some degree regulated by extremes of temperature. Termination of outbreaks of the beetle were found to be associated with low winter temperatures. High summer temperatures did not result in mortality except in felled exposed logs during part of the summer.

77. **BEAL J. A.** 1948. South needs more work research on forest insects. For. Farmer 7(5):24. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION General discussion of southern pine beetle research.

78. **BEAL J. A., BENNETT W. H., KETCHAM D. E.** 1964. Beetle explosion in Honduras. Am. For. 70:31-33. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus mexicanus*). LIFE HISTORY-GENERAL, POPULATION DYNAMICS A massive southern pine beetle epidemic which occurred in Honduras in 1962-64 is described. The epidemic was the worst outbreak of the insect on record, with an estimated 8.5 billion board feet of pine destroyed. The epidemic emphasizes the need for an increased program of research to determine the causes of the phenomenal rise and fall in insect populations.

79. **BEAL J. A., HALIBURTON W., KNIGHT F. B.** 1952. Forest insects of the Southeast: With special reference to species occurring in the Piedmont Plateau of North Carolina. Duke Univ. School of For. Bull. 14., Durham, N. C. 168 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*. CERAMBYCIDAE; *Monochamus titillator, Monochamus carolinensis*. NEMATODA: *Anguillonema* sp.). LIFE HISTORY-GENERAL Gives brief life history and control for the southern pine beetle.

80. **BEAL J. A., MASSEY C. L.** 1945. Bark beetles and ambrosia beetles (Coleoptera: Scolytoidea): With special reference to species occurring in North Carolina. Duke. Univ. School of For. Bull. 10. p. 82-85. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp., *Ips* spp.). LIFE HISTORY-GENERAL, TAXONOMY, SEASONAL OCCURRENCE, DISTRIBUTION, PREDATOR, COMPETITION, VERTEBRATES The southern pine beetle is the most destructive insect pest of southern pines. Periodic widespread epidemics have destroyed more merchantable timber in the South than any other agent. A general life history including range, seasonal distribution, natural controls, and taxonomy is discussed.

81. **BELANGER R. P.** 1979a. Shortleaf pine. *In*, Silvicultural Guidelines for Forest Owners in Georgia. Ga. For. Comm. For. Res. Pap. 6. p. 18-19. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL Southern pine beetle is a pest of pines.

82. **BELANGER R. P.** 1979b. The susceptible forest in the Upper Piedmont. Fact sheet, Ga. For. Comm., Macon, Ga. and USDA For. Serv., Southeast For. Exp. Stn., Asheville, N. C. 1 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS Stand conditions susceptible to the southern pine beetle in the Upper Piedmont are presented.

83. **BELANGER R. P.** 1980a. Chapter 9. Silvicultural guidelines for reducing losses to the southern pine beetle. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Tech. Bull. 1631. p. 165-177. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, CONTROL- CULTURAL Southern pine beetle long-term control must be based on silviculture. Techniques for reducing losses to southern pine beetle include promoting individual tree resistance and protecting the site. Tree resistance can be achieved by favoring resistant species and removing high risk trees. Stand resistance can be increased by maintaining proper density and species composition. Sites may be protected by avoiding soil and stand disturbances. Recommendations are given for the Southern Coastal Plain, the Piedmont and the Southern Appalachians.

84. **BELANGER R. P.** 1980b. Rating the susceptibility of pine stands to southern pine beetle attack. USDA For. Serv. Southeast. Area State and Priv. For. For. Bull. SA-FB/P27. South. Pine beetle fact sheet No. 10. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, HAZARD/RISK RATING Southern pine beetle occurs most frequently in dense overstocked stands.

85. **BELANGER R. P.** 1981a. Piedmont, Georgia. *In*, Site, stand and host characteristics of southern pine beetle infestations, J. E. Coster and J. L. Searcy, Eds. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. 1612. p. 68-74. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS Stands infested by the southern pine beetle in the Upper Piedmont of Georgia usually have a large percentage of the host component in shortleaf pine, a high surface and subsurface clay content, and slow radial growth during the last ten years. Trees initially attacked are dominant or co-dominant pines with large live crown ratios and root systems in incipient stages of decline.

86. **BELANGER R. P.** 1981b. Silvicultural considerations in developing integrated southern pine beetle management procedures. *In*, First Biennial South. Silvi. Res. Conf., Atlanta, Ga., Nov. 6-7, 1980, J. P. Barnett, Ed. USDA For. Serv. Gen. Tech. Rep. SO-34. p. 279-286. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, STAND CONDITIONS Southern pine beetle often occurs in dense, overmature stands. These stand conditions, as well as host and site, must be taken into consideration when managing the southern pine beetle.

87. **BELANGER R. P.** 1981c. Silviculture: A means of preventing losses from the southern pine beetle. USDA For. Serv. For. Pest Manage. South. Pine Beetle Fact Sheet No. 21 For. Bull. SA-FB/P40. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* sp. *Phlebia* sp.). HOST SELECTION, HOST RESISTANCE, CONTROL-CULTURAL, LIGHTNING Several silvicultural options are recommended that may be helpful in developing prevention strategies to reduce southern pine beetle losses. Recommendations include: 1) Favor resistant species, 2) Salvage trees damaged by lightning, wind or ice, 3) Reduction of basal area in dense stands, 4) Encourage mixed pine hardwood stands, 5) Minimize logging damage, 6) Harvest overmature stands, and 7) Encourage site protection. Silvicultural activities related to pest management should not be neglected during periods of low beetle activity.

88. **BELANGER R. P., COULSON R. N., LEWIS J., PAYNE T. L., STEPHEN F. M., TAYLOR J. W., WARD J. G. D., WESTBROOK R. F.** 1979. Southern pine beetle research, applications and implementation activities for the southern forestry community. USDA For. Serv. Sci. and Education Admins. Coop. Res. Pineville, La. 26 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, WOOD UTILIZATION, CONTROL-CHEMICAL, INTEGRATED PEST MANAGEMENT Eight technology transfer teams were formed from the Southern Pine Beetle Technology Transfer Task Force. Teams assigned priority to

eight application areas and rated them as high, medium, and low for attention during the period of October 1, 1979 through September 30, 1980. Continuing research, new research and development, implementation, and future needs are discussed in each category of activities.

89. **BELANGER R. P., HATCHELL G. E.** 1981. Georgia Mountains. *In*, Site, stand and host characteristics of southern pine beetle infestations, J. E. Coster and J. L. Searcy, Eds. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. 1612. p. 82-86. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS Stands attacked and killed by the southern pine beetle in the Georgia Mountains were characterized by dense stocking, slow radial growth, and overmature, predominantly pine species. Attacked plots averaged 62 years of age, 129 ft. square stocking per acre, 16.7 mm of radial growth in the last ten years, and 7.7 mm for the last five years indicating stands in decline. Shortleaf pine and pitch pines were the predominant species attacked.

90. **BELANGER R. P., HATCHELL G. E., MOORE G. E.** 1977. Soil and stand characteristics related to southern pine beetle infestations: A progress report for Georgia and North Carolina. Proc. Sixth South. For. Soils Workshop Oct. 19-21, 1976, Charleston., S. C. p. 99-107. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Phytophthora cinamomi*). ECOLOGICAL DISTRIBUTION, HOST SELECTION, HOST RESISTANCE, HAZARD/RISK RATING Site and soil conditions are closely associated with areas of high southern pine beetle risk in the Georgia Piedmont. Problem southern pine beetle areas coincide with problem littleleaf disease areas. Eroded, abused land covered with shortleaf pine stands appear to be the most susceptible areas to beetle attack.

91. **BELANGER R. P., MALAC B. F.** 1980. Silviculture can reduce losses from the southern pine beetle. USDA Comb. For. Pest Res. and Dev. Prog. Agric. Handb. No. 576. 17 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL This instructional handbook discusses the characteristics associated with stands that are highly susceptible to the southern pine beetle in the Southern Coastal Plain, Piedmont, and Southern Appalachian Region. Four silvicultural techniques are suggested as follows: Promotion of individual tree resistance, promotion of stand resistance, protection of the site, and minimization of disease and competition.

92. **BELANGER R. P., OSGOOD E. A., HATCHELL G. E.** 1979. Stand, soil, and site characteristics associated with southern pine beetle infestations in the Southern Appalachians. USDA For. Serv. Res. Pap. SE-198. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, HOST SELECTION, CONTROL-CULTURAL, STAND CONDITIONS Stand, soil, and site characteristics associated with southern pine beetle infestations in the Southern Appalachians were studied during 1957 and 1975-77. The most destructive outbreaks of the insect occurred on stands characterized by dense stocking, slow radial growth, and a large proportion of overmature sawtimber. Virginia pine and eastern white pine were less susceptible to beetle attack than loblolly pine, pitch pine, and shortleaf pine.

93. **BELANGER R. P., PORTERFIELD R. L., ROWELL C. E.** 1981. Development and validation of systems for rating the susceptibility of natural stands in the Piedmont of Georgia to attack by the southern pine beetle. *In*, Hazard-rating Systems in Forest Insect Pest Management: Symp. Proc., R. L. Hedden, S. J. Barras and J. E. Coster, Tech. Coords., Athens, Georgia, 31 July - 1 August 1980. USDA For. Serv. Gen. Tech. Rep. WO-27. p. 79-86. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS, INTEGRATED PEST MANAGEMENT High-hazard southern pine beetle stands in the Upper Piedmont of Georgia are characterized by a higher proportion of shortleaf pine, slower radial growth, more clay in the surface and subsurface horizons and a deeper surface soil. The system worked well in the Upper Piedmont, but was a poor indicator in the Lower Piedmont.

94. **BELANGER R. P., PRICE T. S.** 1979. The susceptible forest in the Upper Piedmont. Fact sheet, Ga. For. Comm., Macon, Ga. and USDA For. Serv., Southeast For. Exp. Stn., Asheville, N. C. 1 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS Stand conditions susceptible to the southern pine beetle in the Upper Piedmont are presented.

95. **BELANGER R. P., WISEMAN T.** 1979. Pine beetles prefer sick prey. Ala. For. 1979 For. Ind. Dir, p. 25. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, HOST SELECTION, STAND CONDITIONS A review of factors relating host preferences of the southern pine beetle is discussed in popular terms. Soil and site conditions as well as management practices contributing to southern pine beetle epidemics are discussed. Maintaining optimum stocking levels and favoring more resistant species are recommended as good management tools.

96. **BELL J. C., DRAKE L. E., OVERGAARD N. A.** 1967. Southern and Southeastern States. USDA For. Serv. For. Insect Conditions in the United States 1967. p. 29-30. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, OUTBREAKS Southern pine beetle populations had reached epidemic levels in many areas of the South and Southeast in 1967. Severe beetle outbreaks were reported in East Texas, Louisiana, Mississippi, North and South Carolina, Virginia, and Georgia.

97. **BENNETT W. H.** 1955. Pine bark beetles. Tex. For. Serv. Circ. No. 43. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips calligraphus, Ips grandicollis, Ips avulsus*). LIFE HISTORY-GENERAL, CONTROL-GENERAL Notes on the general biology and symptoms associated with *Dendroctonus frontalis, Dendroctonus terebrans, Ips calligraphus, Ips grandicollis*, and *Ips avulsus* are discussed. More detailed descriptions and associated symptoms of attack are given for each species (*Ips* are considered as one group). Two methods of control (rapid utilization and spraying with BHC) are presented. Preventative techniques are discussed.

98. **BENNETT W. H.** 1956. Important insect enemies of southern pines. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep. No. 10, New Orleans, La. 21 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). LIFE HISTORY-GENERAL, CONTROL-GENERAL, CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION Describes the life cycle of the southern pine beetle; includes signs of attack (pitch tubes, boring dust, and foliage color change) and control (salvage logging and BHC) recommendations.

99. **BENNETT W. H.** 1960. What's the pitch with the black turpentine beetle? South. Lumberman 200(2490):35-36. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*). LIFE HISTORY-GENERAL Hypothetical conversation between the southern pine beetle and the black turpentine beetle.

100. **BENNETT W. H.** 1965. Silvicultural control of southern forest insects. Proc. 14th For. Symp., La. State Univ., Baton Rouge, La. p. 51-63. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp.). CONTROL-CULTURAL, REVIEW Southern pine beetle initial attacks are commonly associated with overdense stands, lightning strikes, and pines with negligible growth.

101. **BENNETT W. H.** 1966. The southern pine beetle. USDA For. Serv. Resource Bull. SO-43 27 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL Summarizes life history, distribution and controls for the southern pine beetle.

102. **BENNETT W. H.** 1968. Timber management and southern pine beetle research. For. Farmer 27(9):12-13. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, CONTROL-BIOLOGICAL, MISCELLANEOUS TECHNIQUES Learning how to manage timber stands that are less susceptible to insect pests is one of the most effective controls of the southern pine beetle. Recognizing situations which decrease the resistance of stands to attack are discussed.

103. **BENNETT W. H.** 1971. Silvicultural techniques will help control bark beetles. Proc., 1971 South. Reg. Tech. Conf. (Soc. Am. For.) p. 289-295. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). CONTROL-CULTURAL, STAND CONDITIONS, FIRE Poor tree vigor is the most common factor underlying epidemics of the southern pine beetle. When additional stress such as drought, fire, flooding, or logging damage occurs stands are further weakened and ideal conditions for rapid beetle population increases are created. The resistance of stands to the beetle can be increased by improved management and harvesting practices.

104. **BENNETT W. H., CHELLMAN C. W., HOLT W. R.** 1958. Insect enemies of southern pines. USDA For. Serv. South. For. Exp. Stn. Occas. Pap. No. 164. 35 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*). LIFE HISTORY-GENERAL, REVIEW This publication presents information on the identification, habits, and control of insect pests of the southern pines. This booklet, with numerous line drawings, is intended as an identification aid for woodsworkers, forest managers, and others interested in forest protection.

105. **BENNETT W. H., CIESLA W. M.** 1971. Southern pine beetle. USDA For. Pest Leafl. 49. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp., *Dendroctonus terebrans*). LIFE HISTORY-GENERAL, PREDATOR, PARASITES, CONTROL-GENERAL, CONTROL-CHEMICAL This leaflet outlines the habits of *Dendroctonus frontalis*. Habits covered include hosts, evidences of attack, a brief life history, enemies of the southern pine beetle, silvicultural control, direct control, and pesticide precautions.

106. **BENNETT W. H., OSTMARK H. E.** 1972 Insect pests of southern pines. USDA For. Serv. South. For. Exp. Stn. 1972. 38 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips grandicollis, Ips calligraphus*. CURCULIONIDAE; *Hylobius pales, Pachylobius picivorus*. CERAMBYCIDAE; *Monochamus titillator*. BUPRESTIDAE; *Buprestis apricans*. PLATYPODIDAE; *Platypus* spp.). LIFE HISTORY-GENERAL, CONTROL-GENERAL, CONTROL-CULTURAL, SURVEY AND DETECTION This paper describes the life history and habits of *Dendroctonus frontalis*. *D. frontalis* attacks weakened and damaged trees and may spread over large acreages. Signs of attack include fading crowns, pitch tubes, frass and the typical s-shaped gallery. Salvage logging will check beetle spots only if the infested brood is removed.

107. **BENNETT W. H., PICKARD L. S.** 1966. Benzene hexachloride emulsion as a summer control of the southern pine beetle. J. Econ. Entomol. 59:484. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CHEMICAL, WEATHER RELATIONSHIPS A spray of 1.0% gamma benzene hexachloride in water was tested to see if it equaled the standard 0.5% diesel oil solution as a summer control for the southern pine beetle. In summer use, the emulsion was as effective as the oil; in winter it was less effective.

108. **BERISFORD C. W.** 1974a. Hymenopterous parasitoids of the eastern juniper bark beetle, *Phloesinus dentatus* (Coleoptera: Scolytidae). Can. Entomol. 106:869-872. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Phloesinus dentatus, Ips* spp.). PREDATOR, PARASITES, HOST SELECTION *Phloesinus dentatus* is a pest of weakened eastern red cedar in the eastern U. S. Five parasitoids of *P. dentatus* commonly attack *Dendroctonus frontalis* and *Ips* spp. beetles. When populations of the southern pine beetle are at endemic levels, *P. dentatus* may act as an alternate host for the parasitoids thus allowing high population levels to be maintained.

109. **BERISFORD C. W.** 1974b. Parasite abundance in *Ips* spp. infestations as influenced by the southern pine beetle. Environ. Entomol. 3:695-696. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp.). PREDATOR, PARASITES, POPULATION DYNAMICS, CONTROL-BIOLOGICAL The number of *Ips* spp. beetles attacking felled loblolly pines were found to be greater in areas where southern pine beetle occurs than in areas with no southern pine beetle activity. The total number of parasites attacking were similar while the species variability changed with the presence or absence of the various bark beetles.

110. **BERISFORD C. W.** 1980. Chapter 3. Natural enemies and associated organisms. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Admin. Tech. Bull. 1631. p. 31-52. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). CONTROL-BIOLOGICAL, MITES, NEMATODES Arthropod enemies, avian predators, competitors, pathogenic organisms and symbiotic agents of the southern pine beetle are discussed. Insect predators include clerids, *Corticeus* and others. Parasitic wasps respond to southern pine beetle behavioral chemicals. A model for parasite movement from *Ips* to southern pine beetle trees is given. Mites as predators and phoretic agents are presented. Avian predators include woodpeckers; timber management practices are recommended for increased numbers of woodpeckers. Competitors include pine sawyers, *Ips* and BTB. Nematodes, mycangial and entomophagous fungi are discussed.

111. **BERISFORD C. W., BRADY U. E.** 1981. Selective application of toxicants. *In*, Field and laboratory evaluations of insecticides for southern pine beetle control, Hastings, F. L. and J. E. Coster, Eds. USDA For. Serv. South. For. Exp. Stn. Gen. Tech. Rep. SE-21, Asheville, N. C. p. 16-17. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, MISCELLANEOUS TECHNIQUES A comparison was made between applying insecticides to the whole tree bole, and to certain sections of the bole. Treatment of the lower half of the bole provided little protection from southern pine beetle attack. Treatment of the upper and mid bole gave good protection.

112. **BERISFORD C. W., BRADY U. E., FITZPATRICK G. E., FRANKLIN C. K., HASTINGS F. L., JONES A. S., LASHOMB J. H., MIZELL R. F. III., NEEL W. W., RAGENOVICH I. R.** 1981. Efficacy studies: Prevention. *In*, Field and laboratory evaluations of insecticides for southern pine beetle control, Hastings, F. L. and J. E. Coster, Eds. USDA For. Serv. South. For. Exp. Stn. Gen. Tech. Rep. SE-21, Asheville, N. C. p. 3-8. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, MISCELLANEOUS TECHNIQUES Chlorpyrifos, chlorpyrifos-methyl, fenitrothion, and carbaryl were tested to determine their efficacy in the prevention of southern pine beetle attacks and remedial control. The three experiments conducted were forced attacked tests, changing-bolt tests, and standing tree tests.

113. **BERISFORD C. W., BRADY U. E., FITZPATRICK G. E., LASHOMB J. H., MIZELL R. F. III., NEEL W. W., RAGENOVICH I. R.** 1981. Efficacy studies: Remedial. *In*, Field and laboratory evaluations of insecticides for southern pine beetle control, Hastings, F. L. and J. E. Coster, Eds. USDA For. Serv. South. For. Exp. Stn. Gen. Tech. Rep. SE-21, Asheville, N. C. p. 9-10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, MISCELLANEOUS TECHNIQUES Lindane, chlorpyrifos, fenitrothion, and carbaryl were field tested in Georgia, South Carolina, Mississippi, and Louisiana for their remedial effectiveness against southern pine beetle. The tests were designed to test the efficacy of the chemicals for killing larvae, pupae, and adult southern pine beetles within trees. Separate results were reported for the tests conducted in all four states.

114. **BERISFORD C. W., BRADY U. E., MIZELL R. F., LASHOMB J. H., FITZPATRICK G. E., RAGENOVICH I. R., HASTINGS F. L.** 1980. A technique for field testing insecticides for long-term prevention of bark beetle attack. J. Econ. Entomol. 73:694-697. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). CONTROL-CHEMICAL A technique is described for the evaluation of long term preventative control of the southern pine beetle. Bolts were removed from trees sprayed with the insecticide to be tested, and hung on trees near the active head of a southern pine beetle infestation. The bolts were baited with frontalure, and efficacy was evaluated by the reduction in successful attacks relative to untreated checks.

115. **BERISFORD C. W., BRADY U. E., RAGENOVICH I. R.** 1981. Residue studies. *In*, Field and laboratory evaluations of insecticides for southern pine beetle control, Hastings, F. L. and J. E. Coster, Eds. USDA For. Serv. South. For. Exp. Stn. Gen. Tech. Rep. SE-21, Asheville, N. C. p. 11-12. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, MISCELLANEOUS TECHNIQUES Lindane, chlorpyrifos, chlorpyrifos-methyl, fenitrothion, and carbaryl were tested for persistence on bark by gas liquid chromatographic analysis. Chlorpyrifos was the most persistent, and most toxic, however lindane was superior in providing long-term protection against the southern pine beetle. The persistence of the chemicals was tested under simulated rainfall for emulsifiable concentrate and wettable powder. WP formulations were most compatible with low-drift spray systems.

116. **BERISFORD C. W., TURNBOW R. H., BRADY U. E.** 1982. Selective application of insecticides for prevention of southern pine beetle attack. J. Econ. Entomol. 75:458-461. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Southern pine beetle attacks were prevented by spraying the bole or the top half of the bole only with lindane or chlorpyrifos, Treatment of the lower 2 m and the lower one-half of the tree boles did not prevent attacks.

117. **BERRYMAN A. A.** 1972. Resistance of conifers to invasion by beetle-fungus associations. BioScience 22(10):598-602. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, POPULATION DYNAMICS, BEHAVIORAL CHEMICALS, ATTRACTANTS, HOST SELECTION, HOST RESISTANCE, REVIEW The resistance of conifers to invasion by bark beetle-fungus associations appears to be determined by two defense systems: 1) a preformed, resident, or 'primary' resin canal system, and 2) a hypersensitive reaction which occurs in the tissues surrounding the wood. Hypothetically, these mechanisms function in wound cleansing, containment of infection, and wound healing.

118. **BERRYMAN A. A.** 1974. Dynamics of bark beetle populations: Towards a general productivity model. Environ. Entomol. 3:579-585. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FECUNDITY, POPULATION DYNAMICS, MODELING, STATISTICAL METHODS A general productivity model is proposed which is composed of two components, multiplication and survival. The multiplication model is tentative and needs verification by additional research on other bark beetle species. The survival model is a reasonable representation for two bark beetle species, and appears to explain the general form of productivity curves for two additional species.

119. **BIEL A. K., BRAND J. M., MARKOVETZ A. J., BRIDGES J. R.** 1977. Dimorphism in *Ceratocystis minor* var. *barrasii*. Mycopathologia 62(3):179-182. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Ceratocystis minor* var. *barrasii*). COMMENSALISM AND SYMBIOSIS *Ceratocystis minor* var. *barrasii* is discussed in its symbiotic role with the southern pine beetle. The influence of both carbon dioxide and phosphate in this dimorphism is discussed. A possible life cycle for *C. minor* is suggested.

120. **BIESBROCK J. A., WOODARD J. R., DOWNS S. W.** 1976. Multispectral imagery for detecting southern pine beetle infestations. Bull. Ga. Acad. Sci. (Abst.) 34:59. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION By comparing color, color infrared, and multispectral photographic coverage of southern pine beetle spots, it was preliminarily determined that normal color images yield more readily interpretable information than either of the other two types.

121. **BILLINGS P. D., ROBERTS E. A., PAYNE T. L.** 1981. Controlled-release device for southern pine beetle behavioral chemicals. J. Ga. Entomol. Soc. 16(2):181-185. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS A controlled-release device was developed for the *Dendroctonus frontalis* attractant frontalure. Elution devices with smallest openings (2 or 3 mm) had the lowest and most uniform release rates, while those with larger openings released pheromone erratically. To elute a rate of about 72 mg/tree/day, two dispensers with 4mm openings were optimal.

122. **BILLINGS R. F.** 1974. The Texas Forest Service Southern Pine Beetle Control Program: Analysis of survey and control records to provide a basis for making improved operational decisions. *In*, Southern Pine Beetle Symp., Payne T. L., Coulson R. N., Thatcher R. C., Eds., March 7-8, 1974. Tex. Agric. Exp. Stn. College Station, Tex. p. 54-57. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, SURVEY AND DETECTION A brief description of spot inactivity in Texas as influenced by spot size and season is given. Based on records taken by the Texas Forest Service in 1973, conclusions are drawn relating spot size and season of detection to the probability of the spot becoming inactive.

123. **BILLINGS R. F.** 1977a. Forest industry attitudes toward southern pine beetle control. Tex. For. Serv. Publ. 114. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, ECONOMICS, IMPACT The results of a questionnaire, consisting of 14 alternative approaches to suppression or prevention of southern pine beetle (*Dendroctonus frontalis*) infestations, circulated to administrative, staff, and line officers of major East Texas forest industries is presented. Respondents were asked to evaluate each alternative according to their current management objectives. Respondents were also asked to list current approaches being used to control southern pine beetle. Industry personnel preferred salvage as the main control alternative.

124. **BILLINGS R. F.** 1977b. Pine beetle: Is it too big? Tex. For. 18:6-8. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-BIOLOGICAL, ECONOMICS, IMPACT The southern pine beetle outbreak in Texas is discussed.

125. **BILLINGS R. F.** 1979. Detecting and aerially evaluating southern pine beetle outbreaks. South. J. Appl. For. 3:50-54. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, SURVEY AND DETECTION Using information from aerial detection and control records as well as knowledge of beetle habits, guidelines are set down for ground checking priorities and periodic reevaluation of uncontrolled infestations.

126. **BILLINGS R. F.** 1980a. 'Cut-and-leave' for control of southern pine beetle. For. Farmer 39(10):6-7,18. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL Billings describes cut-and-leave control of the southern pine beetle for forest landowners. The cut-and-leave method is diagrammed.

127. **BILLINGS R. F.** 1980b. Chapter 10. Direct control. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Admin. Tech. Bull. 1631. p. 179-192. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). CONTROL-CULTURAL Direct control of the southern pine beetle includes salvage, cut-and-leave, pile-and-burn and chemicals, including BHC, Lindane and Dursban-4E. Salvage is preferred as a return on investment. Potential controls evaluated include behavioral chemicals and improved detection.

128. **BILLINGS R. F.** 1982a. Have sawmill, will travel. Portable sawmill aids beetle prevention program. Tex. For. News 61:12-13. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION, ECONOMICS A portable sawmill for use with beetle-infested pine is discussed.

129. **BILLINGS R. F.** 1982b. Implementing new southern pine beetle technology in East Texas. *In*, Increasing forest productivity. Proc. 1981 Soc. Am. For. Natl. Meet., Orlando, Fla. p. 184-188. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TECHNOLOGY TRANSFER, HAZARD/RISK RATING, INTEGRATED PEST MANAGEMENT Billings stresses technology transfer for southern pine beetle management. Topics covered include prediction and evaluation, suppression, utilization and prevention.

130. **BILLINGS R. F., BRYANT C. M.** 1982. Southern pine beetle field guide for hazard rating, prevention and control. Tex. For. Serv. Circ. 259. 24 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS A hazard-rating guide for southern pine beetle is presented for field use. Included are diagrams and explanations of variables (landform, pine basal area, and tree height) used in decision making. The use of alternative methods for tree height and basal area measurements are presented.

131. **BILLINGS R. F., DOGGETT C.** 1980. An aerial observer's guide to recognizing and reporting southern pine beetle spots. USDA Comb. For. Pest Res. and Dev. Prog. Agric. Handb. No. 560. 19 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, FIRE Billings and Doggett present an instructional handbook that shows aerial crews: How to recognize southern pine beetle spots on a yearly basis, how to distinguish southern pine beetle spots from other tree problems (disease, fire, etc.), how to evaluate potential spot expansion, how to determine priorities for ground checking based on items one through three, and how to update flight maps for follow-up aerial surveys. In addition, suggested symbols for flight maps and recommendations for regional differences are presented. Procedures were developed from information gathered on the Gulf Coast Region.

132. **BILLINGS R. F., HYNUM B. G.** 1980. Southern pine beetle. Guide for predicting timber losses from expanding spots in East Texas. Tex. For. Serv. Circ. No. 249. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, MISCELLANEOUS TECHNIQUES A guide is presented to estimate tree and inherent dollar losses resulting from spot spread of southern pine beetle attack over a 30 day period based on the variables total stand basal area (square feet/acre), and number of active trees within the current spot. The formula for 'additional trees killed' as well as a table of commonly found values are presented. As a further aid to control decisions, a formula for 'trees remaining active' at the end of the 30 day period is presented. The model is based on 1975 data and is applicable to East Texas spots during the months of June-October only.

133. **BILLINGS R. F., KIBBE C. A.** 1978. Seasonal relationships between southern pine beetle brood development and loblolly pine foliage color in East Texas. Southwest. Entomol. 3:89-95. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, SURVEY AND DETECTION, WEATHER RELATIONSHIPS The foliage of trees attacked during the winter months remained green for two to three times longer than that of trees attacked in the spring and summer. Broods generally emerged from winter-infested trees after the foliage begins to fall, and from summer infested trees when the foliage is yellow.

134. **BILLINGS R. F., PASE H. A. III.** 1979a. A field guide for ground checking southern pine beetle spots. USDA Comb. For. Pest Res. and Dev. Prog. Agric. Handb. No. 558. 19 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Billings and Pase present an instructional manual that shows ground crews: 1) how to locate southern pine beetle spots from ground level, 2) how to identify southern pine beetle attacks and delineate them from those of other bark beetles, 3) how to recognize various stages of attack (fresh, developing brood, vacated) from the months May to October, 4) how to assign control priorities based on items one through three, and 5) how to denote buffer strips for use by control crews.

135. **BILLINGS R. F., PASE H. A. III.** 1979b. Spot proliferation patterns as a measure of the area-wide effectiveness of southern pine beetle control tactics. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan. 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J. L. Eds., USDA For. Serv. Tech. Bull. No. 1613. p. 86-97. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES, CONTROL-CULTURAL Presented is a methodology to estimate treatment efficacy for *Dendroctonus frontalis* which accounts for variations other than control treatments. Results show that control by salvage or cut-and-leave in the summer was followed by a short-term reduction in the subsequent proliferation of new spots. Spots controlled after September resulted in increased proliferation.

136. **BIRCH M. C.** 1978. Chemical communication in pine bark beetles. Am. Sci. 66:409-419. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus, Ips* spp.). BEHAVIORAL CHEMICALS, HOST SELECTION, REVIEW General information on the biology and dispersal of pheromones by bark beetles is discussed. Components of the pheromones of *Ips, Dendroctonus*, and *Scolytus* are presented. Integration of pheromones with other sensory stimuli and modification of those senses as they relate to season and locality are discussed. Sources of pheromones of *Ips* and *Dendroctonus* are presented.

137. **BIRCH M. C., ŠVIHRA P.** 1979. Exploiting olfactory interactions between species of Scolytidae. *In*, Current Topics in For. Entomol. Selected papers from the XVth Internat. Congr. of Entomol., Wash., D.C., August 1976, W.E. Waters, Ed. USDA For. Serv. Gen Tech. Rep. WO-8 p. 135-138. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis, Ips pini, Ips paraconfusus*). COMPETITION, ECOLOGICAL DISTRIBUTION, BEHAVIORAL CHEMICALS, HOST SELECTION The authors explore the possibility of exploiting the inhibitor interactions between the following five species of bark beetle in East Texas: *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, I. calligraphus*, and *I. grandicollis*. Specifically, sequence of attack and distribution of species were studied. The role of olfaction and behavioral interaction were studied. No obvious pheromonal interactions have been singled out to use as control for the five species.

138. **BIRCH M. C., ŠVIHRA P., PAINE T. D., MILLER J. C.** 1980. Influence of chemically mediated behavior on host tree colonization by four cohabiting species of bark beetles. J. Chem. Ecol. 6:395-414. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*). BEHAVIORAL CHEMICALS, ATTRACTANTS An investigation on the sequence of arrival and resource partitioning between cohabiting species of bark beetles on loblolly pine is presented. *Dendroctonus frontalis* and three species of *Ips* coexist in a highly interactive behavioral system in which host trees are colonized very rapidly, while the integrity of mating systems are maintained and disadvantageous reproductive interactions are minimized.

139. **BLACKMAN M. W.** 1922. Mississippi bark beetles. Miss. Agric. Exp. Stn. Tech. Bull. No. 11. 130 p. plus plates. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). LIFE HISTORY-GENERAL, TAXONOMY Briefly summarizes activity of bark beetles in Mississippi. The southern pine beetle had not been located as of 1922.

140. **BLATCHLEY W. S., LENG C. W.** 1916. II. *Dendroctonus* Erichson, 1836. Rhynchophora or weevils of North Eastern America. Nature Pub. Co. Indianapolis. p. 652-653. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TAXONOMY Describes genus *Dendroctonus* and adult of *D. frontalis*.

141. **BLUHM D. R.** 1978. The relationship of size and number of radial resin ducts to oleoresin exudation flow in the four major southern pines. M.S. Thesis, Miss. State Univ., Miss. State. 38 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE The possibility that potential resistance to southern pine beetle attack is related to size and number of radial resin ducts per square centimeter on the southern pines was investigated. The four tree species exhibited large interspecific and intraspecific differences in size and number of resin ducts. *Pinus elliottii* had the highest number of resin ducts, and *P. echinata* had the smallest diameter resin ducts. Flow rate was highest in *P. elliottii* and lowest in *P. palustris*.

142. **BONGBERG J. W.** 1956. A status report on conditions of forest insects in the United States, 1955. FAO Plant Prot. Bull. 4(11):161-163. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, OUTBREAKS Several

large-scale outbreaks of the southern pine beetle are active in North and South Carolina, Tennessee, Georgia, Alabama, and Mississippi. Large-scale control programs are currently being carried out in many areas.

143. **BONGBERG J. W.** 1957. A status report on forest insects in the United States, 1956. FAO Plant Prot. Bull. 5:120. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, SURVEY AND DETECTION Southern pine beetle populations were at epidemic levels in many areas of the South and Southeast. Concentrated control efforts have been successful in reducing beetle numbers in several areas. Overall, populations have subsided from the 1955 level.

144. **BORDEN J. H.** 1974. Aggregation pheromones in the Scolytidae. *In*, Pheromones., North-Holland Publ. Co., Amsterdam. p.136-160. (COLEOPTERA: SCOLYTIDAE). PREDATOR, PARASITES, AGGREGATION, BEHAVIORAL CHEMICALS, FLIGHT, HOST SELECTION General review of aggregation pheromones in the Scolytidae.

145. **BORDEN J. H., STOKKINK E.** 1971. Secondary attraction in the Scolytidae; an annotated bibliography. For. Res. Lab. Can. For. Serv. Info. Rep BC-X-57. 77 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS The authors annotate secondary attraction in the Scolytidae, including *Dendroctonus frontalis*.

146. **BORDEN J. H., VANDERSAR T. H., STOKKINK E.** 1975. Secondary attraction in the Scolytidae: An annotated bibliography. Pest. Manage. Pap. No. 4. 97 p. (COLEOPTERA: SCOLYTIDAE). REVIEW General review of secondary attraction in the Scolytidae.

147. **BOSWORTH A. B., EIKENBARY R. D., FLORA N. W., STURGEON E. E.** 1968. Field key to beetles in pines. Okla. State Univ. Ext. Facts No. 7164. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp., *Ips* spp. CERAMBYCIDAE; *Monochamus titillator*. PLATYPODIDAE; *Platypus* spp. BUPRESTIDAE; *Buprestis apricans*. BOSTRICHIDAE; *Xyleborus* spp.). ADULT, CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL, SURVEY AND DETECTION A description of the bark beetles and wood borers common to southern yellow pines is presented. A pictorial key to both beetles and their galleries is also presented. Brief information on prevention and control is presented for educational purposes.

148. **BÖVING A. G., CHAMPLAIN A. B.** 1920. Larvae of North American beetles of the family Cleridae. Proc. U. S. Natl. Mus. 57:601-602,628-629. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius, Thanasimus formicarius*). PREDATOR Describes larvae of *Thanasimus dubius* and *T. formicarius*, predators of *Dendroctonus frontalis*.

149. **BOZEMAN P. P. III.** 1977. Comparisons of several sources of baseline data describing site and stand characteristics potentially associated with southern pine beetle infestations. M. For. Thesis, Stephen F. Austin State Univ., Nacogdoches. 65 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, SAMPLING Baseline data collected by ESPBRAP personnel were evaluated and compared to data from various sources. There were no suitable sources of baseline data to relate forest conditions to southern pine beetle infestations. The necessary degree of sampling intensity by field crews was investigated.

150. **BRADY U. E., BERISFORD C. W., HALL T. L., HAMILTON J. S.** 1980. Efficacy and persistence of chlorpyrifos, chlorpyrifos-methyl, and lindane for preventive and remedial control of the southern pine beetle. J. Econ. Entomol. 73:639-641. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Lindane (20% EC), chlorpyrifos (Dursban 4EC), and chlorpyrifos-methyl (Reldan 4EC) were compared in field efficacy tests on southern pine beetle in standing, attacked loblolly pines. The persistence of the three insecticides was compared to efficacy data. Results indicated that lindane dissipated more rapidly than either of the other insecticides while 1% and 2% chlorpyrifos was comparable to 0.5% lindane. Three reapplications of adjuvants proved to improve persistence only slightly.

151. **BRAMBLE W. C., HOLST E. C.** 1935. Microorganisms infecting pines attacked by *Dendroctonus frontalis*. Phytopathology 25:7. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Ceratostomella pini*). COMMENSALISM AND SYMBIOSIS A basidiomycete, an ascomycete (referred to as *Ceratostomella pini*), and a new species of yeast are introduced into the bark of southern yellow pines by *Dendroctonus frontalis*. Radial penetration into the sapwood follows attack. Both the basidiomycete and the ascomycete may be responsible for tree mortality when used for inoculation.

152. **BRAMBLE W. C., HOLST E. C.** 1940. Fungi associated with *Dendroctonus frontalis* in killing shortleaf pines and their effect on conduction. Phytopathology 30:881-899. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, COMMENSALISM AND SYMBIOSIS Analysis of shortleaf pine (*Pinus echinata* Mill.) revealed a variety of fungi infecting the sapwood. Varying rates of penetration into the sapwood are presented. Inoculation of fungi into apparently healthy trees is discussed as is its affect on vigor. No conclusions were drawn as to the effect on conduction.

153. **BRAND J. M., BARRAS S. J.** 1977. The major volatile constituents of a Basidiomycete associated with the southern pine beetle. Lloydia 40:398-400. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, COMMENSALISM AND SYMBIOSIS A fungus of the female of *Dendroctonus frontalis*, designated SJB-122, was isolated from the mycangium of the beetle. Three major volatile substances were extracted by means of gas chromatography. Other fungi and their relation to the southern pine beetle are discussed.

154. **BRAND J. M., BRACKE J. W., BRITTON L. N., MARKOVETZ A. J., BARRAS S. J.** 1976. Bark beetle pheromones: Production of verbenone by a mycangial fungus of *Dendroctonus frontalis*. J. Chem. Ecol. 2:195-199. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, COMMENSALISM AND SYMBIOSIS Both *trans*-verbenol and verbenone are important behavioral chemicals to the southern pine beetle. A mycangial fungus of *D. frontalis* was found to transform *trans*-verbenol into verbenone. This may have an important influence on beetle behavior.

155. **BRAND J. M., BRACKE J. W., MARKOVETZ A. J., WOOD D. L., BROWNE L. E.** 1975. Production of verbenol pheromone by a bacterium isolated from bark beetles. Nature 254:136-137. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp., *Ips* spp. *Bacillus cereus*). BEHAVIORAL CHEMICALS, ATTRACTANTS Discusses verbenone pheromone production by *Bacillus cereus*, a bacterium isolated from bark beetles.

156. **BRAND J. M., SCHULTZ J., BARRAS S. J., EDSON L. J., PAYNE T. L., HEDDEN R. L.** 1977. Bark beetle pheromones: Enhancement of *Dendroctonus frontalis* (Coleoptera: Scolytidae) aggregation pheromone by yeast metabolites in laboratory bioassays. J. Chem. Ecol. 3:657-666. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, COMMENSALISM AND SYMBIOSIS Evidence is presented that certain metabolites of yeasts associated with the southern pine beetle can enhance the aggregation pheromone. Three yeasts were isolated and assayed.

157. **BREMER J. E.** 1967. Laboratory studies on the biology and ecology of the southern pine beetle, *Dendroctonus frontalis* Zimm. M.S. Thesis, Tex. A&M Univ., College Station, Tex. 62 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, PUPAE, ADULT, LIFE HISTORY-GENERAL, REARING Optimal temperatures for *Dendroctonus frontalis* development was near 76 degrees F. Four larval instars occurred; head capsule widths were: 1) 0.334; 2) 0.447; 3) 0.601; and 4) 0.802 mm, respectively. Length of the life cycle varied from about 35.6 days at 70 degrees F to 50.5 at 85 degrees F.

158. **BRENDER E. V.** 1977. Controlling southern pine beetles. For. Farmer 36(8):9. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, SURVEY AND DETECTION This general review of the southern pine beetle describes how an infestation spreads in endemic and epidemic situations. An analogy is made between control of the beetle and control of wildfire.

159. **BRIDGES J. R.** 1978. Nitrogen-fixing bacteria associated with bark beetles. Annu. Meet. Am. Soc. Microbiol. (Abst.) 78:85. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus Ips calligraphus. Bacillus* spp.). VECTOR, COMMENSALISM AND SYMBIOSIS, BACTERIA *Dendroctonus frontalis* was cultured on nitrogen-free media to determine the presence of nitrogen fixing bacteria. Bacteria were isolated from *D. frontalis, D. terebrans, Ips avulsus*, and *I. calligraphus*.

160. **BRIDGES J. R.** 1979. An artificial diet for rearing the southern pine beetle, *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae). J. Ga. Entomol. Soc. 14: 278-279. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REARING A freeze-dried phloem medium was developed for laboratory rearing of the southern pine beetle. Thirty-two percent of the larvae reached full maturity. Pupal weight averaged greater than field collected specimens.

161. **BRIDGES J. R.** 1981. Nitrogen-fixing bacteria associated with bark beetles. Microb. Ecol. 7:131-137. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMMENSALISM AND SYMBIOSIS, BACTERIA Nitrogen-fixing bacteria were isolated from adult *Dendroctonus frontalis* emerging from infested bolts in the laboratory.

162. **BRIDGES J. R., GUINN F. H.** 1980. A solid injection technique for studying bark beetle pheromones. Z. Angew. Entomol. 89:54-57. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, MISCELLANEOUS TECHNIQUES A solid injection technique is described for the comparative gas chromatographic study of bark beetle pheromones. Solid injection is rapid, easy to perform, and efficient because it does not involve extraction or the use of an internal standard. The technique requires only one beetle per sample. Results are compared to those using solvent extraction methods.

163. **BRODIE J. E., DEGROOT R. C.** 1976. Water-spray storage: A way to salvage beetle-endangered trees and reduce logging costs. South. Lumberman 232:13-15. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, ECONOMICS, IMPACT, WOOD UTILIZATION This article reports on a pilot test of a salvage operation in which logs cut from a southern pine beetle infestation were stored under water-spray until they could be processed. A description is given of the water-spray storage procedure, along with estimated costs of implementation.

164. **BROTSCHOL J. V., NUNNALLY L., NAMKOONG G., THOMAS H. A.** 1977. Studies on enzyme variation in the southern pine beetle. J. Elisha Mitchell Sci. Soc. 93:2. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MISCELLANEOUS TECHNIQUES, GENETICS Starch gel enzyme electrophoresis was used to analyze the genetic variation of families of *Dendroctonus frontalis*. Genetic variation was noted in seven out of ten enzymes analyzed in North Carolina.

165. **BUCHANAN W. D.** 1964. Southern and Southeastern States. USDA For. Serv. For. Insect Conditions in the U. S. 1964. p. 29-30. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle populations remained at an endemic level in most of the South and Southeast in 1964.

166. **BUCHANAN W. D.** 1965. Southern and Southeastern States. USDA For. Serv. For. Insect Conditions in the U. S. 1965. p. 34-36. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The southern pine beetle was at epidemic levels in much of the South and Southeast in 1965. The most serious outbreaks occurred in Tennessee and South Carolina. Epidemics were also reported in Texas, Louisiana, Mississippi, and Alabama.

167. **BUHYOFF G. J., LEUSCHNER W. A.** 1978. Estimating psychological disutility from damaged forest stands. For. Sci. 24:424-432. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, ECONOMICS, IMPACT, AESTHETICS Regression models were used to predict preferences for landscapes depicted in 35mm color slides. Subject groups with varying familiarity with forestry evaluated a series of forest sources with various levels of insect damage. Preference in all groups drops rapidly as insect damage increases to ten percent of the total forest scene. Decreases after this level are slight.

168. **BUHYOFF G. J., LEUSCHNER W. A., ARNDT L. K.** 1980. Replication of a scenic preference function. For. Sci. 26:227-230. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, AESTHETICS People's visual landscape preferences as a function of insect infestation intensity can be reliably measured. The paper describes a scenic preference function for forested landscapes.

169. **BUHYOFF G. J., LEUSCHNER W. A., WELLMAN J. D.** 1979a. Aesthetic impacts of southern pine beetle damage. J. Environ. Manage. 8:261-267. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, AESTHETICS The aesthetic impacts of *Dendroctonus frontalis* damage are often perceived in different ways by different people. The preferences of subjects differing in their socialization to forest management was studied. The preferences for forested landscapes diminishes with increases in southern pine beetle damage, especially for more knowledgeable subjects.

170. **BUHYOFF G. J., LEUSCHNER W. A., WELLMAN J. D.** 1979b. Southern pine beetle infestation affects esthetic values of forest landscapes. South. J. Appl. For. 3:48-49. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, AESTHETICS Viewers' preferences for forest landscapes suffering from varying stages of southern pine beetle damages were measured. The greatest aesthetic impact occurs when less than 10% of the visible forest area is infested with southern pine beetles. There is also some difference in scenic preferences depending on whether the subject knows that damage they are viewing is the result of a southern pine beetle infestation.

171. **BUHYOFF G. J., RIESENMAN M. F.** 1979. Manipulation of dimensionality in landscape preference judgements: A quantitative validation. Leisure Sci. 2:221-238. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, AESTHETICS Paired comparison methodology was used to scale preferences for landscapes depicted in 35mm color slides. Subject groups were divided into groups varying in their familiarity with forestry. Results indicated that damage dimensionality (ability to recognize and quantify damage) can be manipulated and aesthetic impact measured as a result of changes in a specific landscape dimension.

172. **BUHYOFF G. J., WELLMAN J. D.** 1980. The specification of a non-linear psychophysical function for visual landscape dimensions. J. Leisure Sci. 3:257-272. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AESTHETICS Landscapes were judged for their visual impact.

173. **BUNT W. D.** 1979. Southern pine beetle behavior on the bark of host trees during mass attack. M. S. For. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 52 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, PREDATOR, SEX-RATIOS, MISCELLANEOUS TECHNIQUES, BEHAVIOR Observations were made on the on-bark behavior of adult southern pine beetles during the first four days of mass attack. Twenty-two percent of the beetles entered the host, 43% flew away, 32% dropped off the host, and 2% were devoured by predators. Females spent significantly more time on the bark because of the boring process. Temperature, relative humidity, and percent cloud cover had no significant effect on beetle behavior.

174. **BUNT W. D., COSTER J. E., JOHNSON P. C.** 1980. Behavior of the southern pine beetle on the bark of host trees during mass attack. Ann. Entomol. Soc. Am. 73:647-652. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). BEHAVIOR Observation of southern pine beetles during the first four days of mass attack indicate that 22% of those landing on the bark eventually entered the tree. Other beetles flew away (43%), dropped off (32%), or were eaten (2%). Males spent less total time on the bark than females.

176. **BURKHART H. E., DANIELS R. F.** 1980. Models for southern pine beetle host dynamics. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C. Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 157-163. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING, MISCELLANEOUS TECHNIQUES Stand models were developed for loblolly pine using individual trees as the basic unit. The models provide a means of evaluating silvicultural practices that might be useful in control of southern pine beetle population levels .

176. **BUSHING R. W.** 1965. A synoptic list of the parasites of Scolytidae (Coleoptera) in North America north of Mexico. Can. Entomol. 97:449-492. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TAXONOMY, PARASITES The following parasites were associated with *Dendroctonus frontalis*: *Coeloides pissodis, Dendrosoter sulcatus, Doryctes* sp. *Ecphylus schwarzii, Spathius canadensis, Spathius pallidus, Vipio rugator, Cecidostiba dendroctoni, Heydenia unica, Liodontomerus* sp., and *Roptrocerus ecoptogastri.*

177. **CAIRD R. W.** 1935. Physiology of pines infested with bark beetles. Bot. Gaz. 96:709-733. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus*). LIFE HISTORY-GENERAL, HOST SELECTION, SURVEY AND DETECTION After initial bark beetle attack, rapid physiological changes occur in the tree. A combination of bole drying and fungus invasion causes tree decline.

178. **CALLAHAM R. Z., SHIFRINE M.** 1960. The yeasts associated with bark beetles. For. Sci. 6:146-154. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus brevicomis, Dendroctonus pseudotsugae, Dendroctonus valens, Dendroctonus engelmanni, Ips typographus, Ips pini, Ips grandicollis, Ips avulsus, Ips oregoni, Ips calligraphus, Ips emarginatus. Zygosaccharomyces pini* = *Pichia pini*). REVIEW, COMMENSALISM AND SYMBIOSIS The authors review the yeasts associated with bark beetles.

179. **CAMORS F. B. JR., PAYNE T. L.** 1972. Response of *Heydenia unica* (Hymenoptera: Pteromalidae) to *Dendroctonus frontalis* (Coleoptera: Scolytidae) pheromones and a host-tree terpene. Ann. Entomol. Soc. Am. 65:31-33. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. HYMENOPTERA: PTEROMALIDAE; *Heydenia unica*). LARVAE, PREDATOR, PARASITES, BEHAVIORAL CHEMICALS, ATTRACTANTS, HOST SELECTION *Heydenia unica* is a larval parasite of *Dendroctonus frontalis*. It was attracted in significant numbers to olfactometers baited with beetle pheromones and host tree terpenes. The host tree terpene attracted more *H. unica* than did the individual pheromones.

180. **CAMORS F. B. JR., PAYNE T. L.** 1973. Sequence of arrival of entomophagous insects to trees infested with the southern pine beetle. Environ. Entomol. 2:267-270. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, PUPAE, ADULT, PREDATOR, PARASITES, BEHAVIORAL CHEMICALS, ATTRACTANTS, MISCELLANEOUS TECHNIQUES The sequence of arrival of entomophagous insects may rely on the presence of beetle- and/or host-produced odors. Five predators and six parasites of the southern pine beetle (*Dendroctonus frontalis*) were trapped throughout all life stages of a southern pine beetle infested tree to check the arrival sequence. Predators were found to arrive early in the attack while parasites continued to increase as the larval stages aged.

181. **CAMPBELL J. B., SMITH K. E.** 1978. Climatological forecasts of southern pine beetle infestations. Proc. 33rd Annu. Meet. Southeast. Div. Assoc. Am. Geogr., Athens., Ga. Nov. 1978. (Abstr.) (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Weather variables are used for southern pine beetle prediction in North Carolina and Arkansas.

182. **CAMPBELL J. B., SMITH K. E.** 1980. Climatological forecasts of southern pine beetle infestations. Southeast. Geogr. 20:16-30. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING, WEATHER RELATIONSHIPS This study is taken from selected data in North Carolina and Arkansas. Multiple regression models are used to show relationships between the location and severity of southern pine beetle infestations as well as climate variations. The models developed are for small multi-county regions using several previously unexamined variables.

183. **CANN J. J.** 1952. The beetle battle. A fight for survival in Mississippi. South. Lumberman 185(2321):151-153. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL During the 1952 outbreak of southern pine beetle in southwestern Mississippi, a large control team was established. Interagency cooperation was the key to controlling the pest. This is explained in an easy-to-read story of the events and conclusions.

184. **CARRUTH H.** 1941. Save the tree! Naval Stores Rev. 15 (19):6. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION A brief note describing weakened pines as susceptible to southern pine beetles.

185. **CARY A.** 1932. On the recent drought and its effects. Naval Stores Rev. 17:14-15; 18:14-15,20; 19:14-15,18. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS, SURVEY AND DETECTION The southern pine beetle was epidemic throughout the southeastern United States in 1931-1932.

186. **CHAMBERLAIN W. J.** 1939. Bark and timber beetles of North America. Oregon State Coll. Coop. Assoc., Corvallis, Oregon. 513 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*). TAXONOMY The bark beetles of southern pines are indexed along with their natural enemies.

187. **CHAPMAN H. H.** 1942. Enemies of loblolly pine, p. 143-146. *In*, Management of loblolly pine in the pine-hardwood region of Arkansas and in Louisiana west of the Mississippi River. Yale Univ. School For. Bull. 49. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp. CERAMBYCIDAE; *Monochamus titillator*). LIFE HISTORY-GENERAL, CONTROL-CULTURAL, REVIEW, FIRE, LIGHTNING Reviews susceptibility of loblolly pine to *Dendroctonus frontalis*. Pines attacked are usually stressed by drought, lightning, fire, and windthrow. Brood may be destroyed by felling infested trees and leaving them in the sun; peeling will also kill the brood.

188. **CHELLMAN C. W., WILKINSON R. C.** 1975. Recent history of the southern pine beetle, *Dendroctonus frontalis* Zimm., (Coleoptera: Scolytidae) in Florida. Fla. Entomol. 58:22. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, DISTRIBUTION, ECONOMICS, IMPACT, REVIEW In this short article, tree susceptibility is discussed as well as recent losses and possible expected losses caused by the southern pine beetle in Florida.

189. **CHITTENDEN F. H.** 1897. Insect injury to chestnut and pine trees in Virginia and neighboring States. USDA Div. Entomol. Bull. No. 7. p. 67-75. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The southern pine beetle was reported to be killing pine trees in Virginia, West Virginia, and the District of Columbia in 1897.

190. **CHITTENDEN F. H.** 1899. Insect enemies of the white pine. USDA Div. For. Bull. 22. p. 55-56. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, POPULATION DYNAMICS, DISTRIBUTION, CONTROL-CHEMICAL, CONTROL-CULTURAL A report on the distribution and destructiveness

of the southern pine beetle, then called the destructive pine beetle, in the decade preceeding the year 1899, is presented.

191. **CHITTENDEN F. H.** 1904. The principal injurious insects of 1903. USDA Yearb. 1903. p. 563-566. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION After years of absence, the southern pine beetle appeared in Georgia.

192. **CHRYSTAL R. N.** 1935. Bark-beetle outbreak and their control: A review of some recent literature. For. 9:124-135. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL Bark beetle control is reviewed.

193. **CIESLA W. M.** 1966. Southern pine beetle attacks red pine in North Carolina. J. For. 64(6):397. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, HOST SELECTION, COMMENSALISM AND SYMBIOSIS Red pine (*Pinus resinosa*) is an exotic in western North Carolina. Southern pine beetle infestations were detected in two red pine plantations. Data on brood development and associated insects are presented.

194. **CIESLA W. M.** 1979. Evaluation of control tactics for southern pine beetle: Have user needs been met? *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 112-116. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL Ciesla presents his evaluation of the symposium entitled, 'Evaluating control tactics for southern pine beetle' sponsored by the Expanded Southern Pine Beetle Research and Applications Program (ESPBRAP). In doing so, he stresses the importance of evaluating control tactics and the users that are affected. He stresses the need of user orientation as a sound basis for future programs.

195. **CIESLA W. M., BELL J. C. JR., CURLIN J. W.** 1967. Color photos and the southern pine beetle. Photogrammetric Eng. 33:883-888. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES Fifty acre plots were transferred onto color aerial photographs for estimating the level of southern pine beetle infestations. Two film types were used, Ansochrome D200 and Ektachrome Infrared Aero. Southern pine beetle trees were located and field checked. Ansochrome D200 was superior because it discriminated between pines and hardwoods better and was capable of penetrating haze.

196. **CLARK E. W.** NONE. Insectos asociados con *Dendroctonus frontalis* Zimmerman in Honduras (Associate insects of *Dendroctonus frontalis* Zimm. in Honduras). Cent. Tech. Evaluacion For. p. 41-47. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, CONTROL-BIOLOGICAL Thirty insect species were found associated with *Dendroctonus frontalis* in Honduras. Nine of these were known biological control agents. Clerids and ostomids were found at a level considered sufficient for control.

197. **CLARK E. W.** 1965a. An artificial diet for the southern pine beetle and other bark beetles. USDA For. Serv. Res. Note SE-45. 3 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). REARING, MISCELLANEOUS TECHNIQUES This research note describes an artificial diet used for the southern pine beetle and *Ips* sp. The medium is described and a 'recipe' is given. Woodborers and Pales weevils have also been successfully reared.

198. **CLARK E. W.** 1965b. A simple rearing technique for obtaining eggs or young larvae of the southern pine beetle. USDA For. Serv. Res. Note SE-44. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REARING, MISCELLANEOUS TECHNIQUES, EGG, LARVAE A simple technique for maintaining a constant, easy access source of southern pine beetle eggs and larvae is presented (diagrams included).

199. **CLARK E. W.** 1973. The adverse effects of high temperatures on the southern pine beetle *Dendroctonus frontalis* Zimmerman. For. Sci. Lab., Res. Triangle Park, N. C.:1-10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS High temperatures decreased populations of the southern pine beetle.

200. **CLARK E. W., OSGOOD E. A. JR.** 1964a. Mass rearing the southern pine beetle and the coarse writing engraver. USDA For. Serv. Res. Note SE-30. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips calligraphus*). EMERGENCE, REARING In order to provide a continuous, controllable supply of uniform southern pine beetle specimens, a rearing chamber was developed. The chamber contains a joined emergence and rearing container. Advantages to the system are: 1) no demanding environmental requirements, 2) low unit cost, and 3) beetles can be reared at a constant population or can be quickly increased in a short time.

201. **CLARK E. W., OSGOOD E. A. JR.** 1964b. An emergence container for recovering southern pine beetles from infested bolts. J. Econ. Entomol. 57:783-784. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EMERGENCE, TRAPS AND CAGES, REARING This paper describes an emergence container developed for the collection of *Dendroctonus frontalis* from infested bolts. It consists of a common trash can and plastic funnel leading into a Mason jar. The emergence container has proved economical and efficient, collecting more than 95% of the beetles emerging from infested bolts.

202. **CLARK E. W., OSGOOD E. A. JR.** 1966. Southern pine beetles. *In*, Insect Colonization and Mass Prod., Academic Press Inc. N.Y. 1966 p. 305-310. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Scolytus multistriatus*, *Hylurgopinus rufipes*, *Ips calligraphus*). EMERGENCE, REARING, TRAPS AND CAGES Southern pine beetle (*Dendroctonus frontalis*) rearing is discussed. In the discussion, rearing chambers, rearing records, ventilation, diets, and associated problems are covered.

203. **CLARKE A. L., WEBB J. W., FRANKLIN R. T.** 1979. Fecundity of the southern pine beetle in laboratory pine bolts. Ann. Entomol. Soc. Am. 72:229-231. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, FECUNDITY, HOST RESISTANCE, REARING Individual female egg production was investigated for the southern pine beetle along with associated gallery patterns in bolts of loblolly pine in the laboratory. Average fecundity was found to be 159 (plus or minus) 12.6 eggs per female. Weak correlations were found for female body length and gallery length and number of niches per gallery; also for niches per cm gallery with phloem moisture. Strong correlations were found between body weight and body length as well as niches per gallery and gallery length.

204. **CLAUSEN C. P.** 1956. Southern pine beetle. Biological control of insect pests in the continental United States. USDA Tech. Bull. No. 1139. p. 67. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus formicarius*). CONTROL-BIOLOGICAL In 1892-93 A. D. Hopkins conducted investigations in Germany and noted a clerid beetle, *Thanasimus formicarius* was abundant. A total of 6098 adult beetles and larvae were imported to West Virginia. A total of 2200 were released. No field recoveries were made.

205. **CLERKE W. H., PRICE T., WILSON E. T.** 1972. Evaluations of southern pine beetle infestations in Georgia-1972. Ga. For. Comm. and USDA For. Serv. Southeast. Area, State and Pri. For. For. Pest Manage. Group, Rep. No. 73-1-17. 21 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, SURVEY AND DETECTION, CONTROL-GENERAL Southern pine beetle infestation evaluations were conducted in 46 counties in central and northern Georgia during September and October of 1972. Results showed a rapid increase in southern pine beetle populations during 1972. It was predicted that 1973 would have even a larger outbreak with increased tree mortality.

206. **CLERKE W. H., WARD J. D.** 1979. Estimating tree mortality over extensive areas. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 75-85. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, MODELING, HAZARD/RISK RATING Tree mortality must first be evaluated in developing southern pine beetle impact surveys, biological evaluations, and suppresion projects. A

flexible three-stage sampling design for mortality estimation and a sampling design for periodic mortality estimation are presented. It is hoped procedures developed here will be used on an operational basis throughout the South. Aerial detection methods using Avery's volumeTree mortality must first be evaluated in developing southern pine beetle impact surveys, biological evaluations, and suppresion projects. A flexible three-stage sampling design for mortality estimation and a sampling design for periodic mortality estimation are presented. It is hoped procedures developed here will be used on an operational basis throughout the South.

207. **COLEMAN V. R.** 1976. Southern pine beetle control. Coop. Ext. Serv. Univ. Ga. Coll. Agric., Athens, Ga. Leafl. 181. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW, CONTROL-GENERAL A brief guide to recognizing a southern pine beetle infestation with guidelines for control is presented. Included are sections on symptoms of attack, life history, control, and pesticide precautions.

208. **COOK S. P.** 1982. Within-tree distributions and interspecific competition between *Dendroctonus frontalis* Zimmermann, *Ips avulsus* (Eichhoff), and *I. calligraphus* (Germar). M. S. Thesis, Tex. A&M Univ., College Station, Tex. 99 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus*). COMPETITION, DISTRIBUTION Competition between the southern pine beetle and pine engraver beetles are presented.

209. **COOPER M. E.** 1978. Parent adult re-emergence in southern pine beetle populations. M.S. Thesis, Univ. Arkansas, Fayetteville, Arkansas. 42 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, EMERGENCE, SEX-RATIOS, MISCELLANEOUS TECHNIQUES Shortleaf pines were sampled for southern pine beetle parent adult reemergence during a 14 month period. Logs were placed in the laboratory, reemerging adults were counted and sexed, and data were collected on attack density, gallery length, and numbers of reemergence holes. Analysis revealed that 65% of attacking beetles reemerged.

210. **COOPER M. E., STEPHEN F. M.** 1978. Parent adult reemergence in southern pine beetle populations. Environ. Entomol. 7:574-577. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, LIFE HISTORY-GENERAL, SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS The potential for predicting parent adult reemergence of the southern pine beetle by using more commonly measured variables such as attack density, gallery length, and number of reemergence holes was investigated. Parent adults were counted and sexed after reemergence in laboratory logs. Attack density and reemergence hole density were linearly related to the total number of beetles reemerging.

211. **COPONY J. A., MORRIS C. L.** 1972. Southern pine beetle suppression with frontalure and cacodylic acid treatments. J. Econ. Entomol. 65:754-757. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL, TRAPS AND CAGES In a heavily infested stand in eastern Virginia, loblolly pine trap trees were set up by baiting them with frontalure and poisoning them with cacodylic acid (S. Werstar 510) in the spring. Frontalure was successful in attracting beetles to trap trees; cacodylic acid treatments resulted in a 3.5 fold increase in aborted attacks and reduced the brood by 59.9%. Applications earlier in the spring may be warranted.

212. **COSTER J. E.** 1967. Studies of the attack behavior of the southern pine beetle *Dendroctonus frontalis* Zimm. M. S. Thesis, Tex. A&M Univ., College Station, Tex. 104 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS, DISTRIBUTION, BEHAVIORAL CHEMICALS The southern pine beetle attack process was investigated.

213. **COSTER J. E.** 1969. Observations on *Platypus flavicornis* (Coleoptera: Platypodidae) in southern pine beetle infestations. Ann. Entomol. Soc. Am. 62:1008-1011. (COLEOPTERA: PLATYPODIDAE; *Platypus flavicornis*; SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, ATTRACTANTS, FLIGHT, HOST SELECTION The ambrosia beetle, *P. flavicornis*, attacks the lower stem of pines which have been previously mass-attacked by the southern pine beetle. Four to six days elapse from the time of attack by *D. frontalis* until *P. flavicornis* lands on the trees. It is suggested that the attacks are oriented primarily to odors produced by the host tree.

214. **COSTER J. E.** 1970a. Certain aspects of pheromone release and aggregation behavior in the southern pine beetle (Coleoptera: Scolytidae). Ph.D. Diss., Tex. A&M Univ., College Station, Tex. 129 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS Aggregation of *D. fronatlis* is brought about by frontalin, *trans*-verbenol and host tree volitiles. Frontalin and *trans*-verbenol were in greatest quantities in unfed females. Hindguts of mated females that had fed contained less frontalin and *trans*-verbenol than unmated females. Beetles responding to host material containing virgin females had a ratio of 1:0.8 (males:females). If crushed males and females were used, the sex ratio changed to 1:1.6, possibly due to verbenone. A series of events in host selection and aggregation behavior of *D. frontalis*, using a sex ratio regulator, was hypothesized.

215. **COSTER J. E.** 1970b. Production of aggregating pheromones in re-emerged parent females of the southern pine beetle. Ann. Entomol. Soc. Am. 63:1186-1187. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS Pheromone production from reemerged attacking adult female southern pine beetle differed qualitatively and quantitatively from that produced by virgin attacking adult females. The ability of reemerged females to produce the pheromone indicates its role as an aggregating pheromone rather than a sex pheromone, and coupled with estimated reemergence of 50-60% indicates that reemerged females may play an important role in southern pine beetle population dynamics.

216. **COSTER J. E.** 1972. Certain aspects of pheromone release and aggregation behaviour in the southern pine beetle, *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae). Folia. Entomol. Mex. 24:86-87. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS Two insect-produced compounds, frontalin and *trans*-verbenol, along with host tree oleoresins, are responsible for aggregations of the southern pine beetle. Factors responsible for this principle are discussed.

217. **COSTER J. E.** 1977. Towards integrated protection from the southern pine beetle. J. For. 75:481-484. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, INTEGRATED PEST MANAGEMENT Coster discusses movement away from direct control of the southern pine beetle toward indirect methods of southern pine beetle control. Managing for resistant stands, biotic control agents, manipulation of stand density, and cutting practices are all discussed as indirect control methods. A discussion of integrated pest management is included.

218. **COSTER J. E.** 1979. Developing a southern pine beetle management system. *In*, Proc. 1978 Natl. Meet., Soc. Am. For., St. Louis., Mo. p. 281-283. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, MODELING, INTEGRATED PEST MANAGEMENT Coster discusses the Expanded Southern Pine Beetle Research and Applications Program within the framework of the Waters-Ewing integrated pest management conceptual model. Specific discussion is aimed at insect and host dynamics, impact, and treatments. ESPBRAP contributions to detection, prediction, and suppression are discussed.

219. **COSTER J. E.** 1980. Chapter 11. Developing integrated management strategies. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Admin. Tech. Bull. 1631. p. 195-203. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*).

INTEGRATED PEST MANAGEMENT The incorporation of southern pine beetle management with resource management is discussed in the context of integrated pest manangment. Southern pine beetle decision support systems are presented.

220. **COSTER J. E., GARA R. I.** 1968. Studies on the attack behavior of the southern pine beetle. II. Response to attractive host material. Contrib. Boyce Thompson Inst. 24:69-75. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS, FLIGHT, HOST SELECTION, BEHAVIORAL CHEMICALS, POPULATION DYNAMICS, DISTRIBUTION Flight, landing and gallery construction activities of the southern pine beetle were investigated. Highest frequencies of all activities occurred in the immediate vicinity of host material due to olfactory stimuli. Under epidemic conditions trees in the immediate vicinity were readily attacked; under endemic conditions this behavior was restricted to the original attraction center. Beetle flight terminated when wind speeds exceeded 4.5 mph.

221. **COSTER J. E., HERTEL G. D.** 1980. New southern pine beetle information. Consultant 25:35-37. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, CONTROL-GENERAL, CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION, ECONOMICS, IMPACT, MODELING, MISCELLANEOUS TECHNIQUES, WOOD UTILIZATION, HAZARD/RISK RATING The Expanded Southern Pine Beetle Research and Applications Program (ESPBRAP) is discussed. A brief summary of practical findings is presented. Included are sections on stand rating systems, utilizing southern pine beetle-killed timber, socioeconomic guidelines, new insecticides and improved spray systems, sampling methods and predictive models, aerial survey and navigation systems, behavioral chemicals, and integrated forest pest management strategies.

222. **COSTER J. E., HICKS R. R. JR., WATTERSTON K. G.** 1978. Directional spread of southern pine beetle (Coleoptera: Scolytidae) infestations in East Texas. J. Ga. Entomol. Soc. 13:315-321. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, WEATHER RELATIONSHIPS Direction of spread of the southern pine beetle was studied in 396 spots in East Texas. To determine this relationship to that of wind direction, wind patterns were taken in Lufkin, Texas where records were kept. Most infestations spread with the prevailing wind (toward the Northwest).

223. **COSTER J. E., JOHNSON P. C.** 1979a. Characterizing flight aggregation of the southern pine beetle. Environ. Entomol. 8:381-387. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, TRAPS AND CAGES, MODELING A comparison of five methods of characterizing aggregation of flying southern pine beetles caught on a systematic grid of sticky traps suggested that Iwao's regression of mean crowding on mean quadrant density provides more information than Taylor's power function, the coefficient of dispersion, Lloyd's index of patchiness, or Morisita's index of dispersion. Lloyd's index (numerically equivalent to Morisita's) is recommended for comparisons between daily catch patterns. Use of 95% prediction limits about the mean-crowding/mean regression enables comparisons of daily patterns to the species norm.

224. **COSTER J. E., JOHNSON P. C.** 1979b. Dispersion patterns of *Dendroctonus frontalis* and its predator *Thanasimus dubius*: Influence of behavioral chemicals. *In*, Dispersal For. Insects.: Evaluation, Theory, and Manage. Implications, IUFRO: Zurich, Switzerland, Sept 4-9, 1978. Bull. Swiss Entomol. Soc. 52:309-322. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, AGGREGATION, BEHAVIORAL CHEMICALS, STATISTICAL METHODS Spatial aggregation patterns for the southern pine beetle are discussed. *Dendroctonus frontalis* and a predator, *Thanasimus dubius*, aggregation patterns were determined in five natural infestations from 1974-1976. Index of patchiness and Iwao's technique of regressing mean crowding on mean density served as qualifiers for aggregation patterns. Both species exhibited clumped dispersion patterns. Aggregation of *T. dubius* populations was directly related to that of *D. frontalis*. Probability of attack was inversely related to distance from previously attacked tree. Pheromonal control strategies are discussed.

225. **COSTER J. E., PAYNE T. L.** 1974. Aggregation behavior of the southern pine beetle and its associates. *In*, Southern Pine Beetle Symp., Payne T. L., Coulson R. N., Thatcher R. C., Eds., March 7-8, 1974. Tex. Agric. Exp. Stn., College Station, Tex. p. 39-40. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*. OSTOMIDAE; *Temnochila virescens*). BEHAVIORAL CHEMICALS, ATTRACTANTS, TRAPS AND CAGES The authors discuss the research aims of Stephen F. Austin State University, the Texas State Agricultural Experiment Station, Texas A&M University, and the USDA Forest Service Cooperative Project initiated in 1971. Preliminary results of field studies are presented. Specific studies, briefly discussed, involve patterns of response and attack, unidentified attractive and repellent compounds, and response of associated insects. The role of pheromones toward an integrated solution is emphasized.

226. **COSTER J. E., PAYNE T. L., EDSON L. J., HART E. R.** 1978. Influence of weather on mass aggregation of southern pine beetles at attractive host trees. Southwest. Entomol. 3:14-20. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, FLIGHT, WEATHER RELATIONSHIPS Precipitation, relative wind velocity, temperature, percent cloud cover and relative humidity were observed for a period of 11 consecutive days on 12 trees adjacent to a natural infestation of southern pine beetle. Wind velocity was found to be the only parameter closely associated with southern pine beetle numbers. At 0900 hours, all parameters were significantly correlated. But at 1900, only wind velocity and relative humidity were significant predictors. None of the parameters were significant in the intervening times. Increased wind velocity was generally associated with reduced trap catches. Trap catches were significantly higher during rainy periods.

227. **COSTER J. E., PAYNE T. L., HART E. R., EDSON L. J.** 1977a. Aggregation of the southern pine beetle in response to attractive host trees. Environ. Entomol. 6:725-731. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, AGGREGATION, BEHAVIORAL CHEMICALS, FLIGHT Infested pine bolts were used to attract southern pine beetles to shortleaf pines. Sticky traps were suspended along the tree boles to monitor the ensuing mass attack period. Mass attack was usually initiated within 24 hours and traps at three to four meters above ground caught the greatest number of beetles. Peak trap catch occurred on the third day of attack and declined rapidly thereafter.

228. **COSTER J. E., PAYNE T. L., HART E. R., EDSON L. J.** 1977b. Seasonal variations in mass attack behavior of southern pine beetle. J. Ga. Entomol. Soc. 12:204-211. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, AGGREGATION, DISTRIBUTION, SEX-RATIOS, TRAPS AND CAGES Adults of southern pine beetle (*Dendroctonus frontalis* Zimm.), trapped on baited trees adjacent to a natural infestation, were observed from 1973 through 1974. Total number and sex ratio did not differ between the seasons of spring (May) and summer (July-August). However, rate of arrival and occurrence at less than three meters above ground was greater in the spring. Flight activity peaked at 1700 hours in both seasons.

229. **COSTER J. E., PAYNE T. L., LORIO P. L. JR., HODGES J. D.** 1973. Southern pine beetle control techniques and strategies. Southern pine beetle - A management challenge. Entomol. Soc. Am. Natl. Meet., Dallas, Tex. 17 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, VERTEBRATES, CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL, CONTROL-CULTURAL, REVIEW, INTEGRATED PEST MANAGEMENT, STAND CONDITIONS, NEMATODES, BACTERIA, LIGHTNING Forest pest management must be extended and integrated into resource management. Southern pine beetle applied controls, including chemicals, and indirect control are reviewed as are natural southern pine beetle controls (clerids, birds, bacteria, fungi, nematodes, mites, and climatological factors). Host and

stand relationships are discussed; infested stands are characterized by poorly drained soils, over-stocked stands, poor water regime, lightning-struck trees and host physiological changes. These aspects must be developed into an integrated resource management scheme.

230. **COSTER J. E., RAGENOVICH I. R. 1976.** Effects of six insecticides on emergence of some parasites and predators from southern pine beetle infested trees. Environ. Entomol. 5:1017-1021. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Corticeus glaber*; *Coelotides pissodis*; *Medetera bistriata*; *Roptrocerus xylophagorum*; *Thanasimus dubius*). PREDATOR, PARASITES, EMERGENCE, CONTROL-CHEMICAL The six insecticides (lindane, phosmet, diazinon, acephate, propoxur, and carbaryl) were applied to bolts taken from southern pine beetle (*Dendroctonus frontalis*) infested trees in East Texas. A total of eleven species of predators and parasites associated with the southern pine beetle emerged from the insecticide-treated bolts taken in this study. Diazinon was the only chemical that significantly reduced emerging insect numbers. Prevalence of specific species and their apparent reductions are presented.

231. **COSTER J. E., SEARCY J. L., EDS. 1979.** Evaluating control tactics for the southern pine beetle. USDA For. Serv. Tech. Bull. No. 1613. 118 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, CONTROL-GENERAL, BEHAVIORAL CHEMICALS, MODELING Control tactics for the southern pine beetle are presented as a symposium. Topics covered include cultural control, manipulation of populations with pheromones, and control tactics on an area-wide basis.

232. **COSTER J. E., SEARCY J. L., EDS. 1981.** Site, stand, and host characteristics of southern pine beetle infestations. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. No. 1612. 115 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). INTEGRATED PEST MANAGEMENT, REVIEW, LIGHTNING This southern pine beetle handbook summarizes research on sites, stand, and host conditions associated with the southern pine beetle. Included are data for the Gulf Coastal Plains, (including eastern Texas, southern Arkansas, southern Mississippi, and Louisiana, and associations of annosus root rot with southern pine beetle attack) the Piedmont regions of Georgia and North Carolina, the Georgia mountains, and characteristics of southern pine beetle infestations across the southern United States. Stand stocking level, mean radial growth rate, and basal area were consistently related to southern pine beetle activity. The most common stand disturbances were lightning and recent logging activity (less than one year old). In the Coastal Plain, infestations occurred most often on wet, low-lying sites of higher site index. Loblolly pine (shortleaf pine in Arkansas) was the preferred host. In the Piedmont, shortleaf pine stands with reduced radial growth were more susceptible. Surface soil depth, soil pH, and eroded heavy clay soils were more important in the Piedmont. In the mountains, stands had relatively high volume and lower-than-normal growth rates.

233. **COSTER J. E., VITÉ J. P. 1972.** Effects of feeding and mating on pheromone release in the southern pine beetle. Annu. Entomol. Soc. Am. 65:263-266. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, HOST SELECTION Hindgut content of the aggregation pheromones frontalin and *trans*-verbenol are maximum in unfed emergent females (GLC of dissected hindguts), and dropped off to 29% and 5% of initial content (respectively) after 48 hours of feeding. Response of field populations to females feeding in host material, however, increased through 24-48 hours of feeding, followed by declining response. Capture of pheromone by frass particles apparently accounts for the increasing response even though pheromone production was declining.

234. **COULSON R. N. 1973.** The southern pine beetle population system. Southern pine beetle - A management challenge. Entomol. Soc. Am. Natl. Meet., Dallas, Tex. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, POPULATION DYNAMICS, REVIEW, SAMPLING Coulson integrates quantitative aspects of the southern pine beetle population system into population management. Coulson discusses the southern pine beetle life system and stresses the need to break the system into component parts. Sampling the system must be based on an array of component variables: climate and weather, tree species, tree size, tree density, tree age, physiology, tree condition; these variables are interactive with: predation, parasitism, interspecific competition, intraspecific competition and disease. These variables must be looked at interactively through research and simulation models in the development of a pest management system.

235. **COULSON R. N. 1974.** Southern pine beetle population dynamics. *In*, Southern Pine Beetle Symp., Payne T. L., Coulson R. N., Thatcher R. C., Eds., March 7-8, 1974. Tex. Agric. Exp. Stn., College Station, Tex. p. 26-31. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING Coulson discusses the philosophical rationale for studying the population dynamics of the southern pine beetle, *Dendroctonus frontalis*. He describes the methodology and structure of population dynamics studies at Texas A&M University and examines the present status of the studies.

236. **COULSON R. N. 1979.** Population dynamics of bark beetles. Annu. Rev. Entomol. 24:417-447. (COLEOPTERA: SCOLYTIDAE). LIFE HISTORY-GENERAL, REVIEW, POPULATION DYNAMICS This review of Scolytid bark beetle literature from a population dynamics framework, beginning at the individual tree level and working through infestations to area-wide considerations, focuses on potential contributions to population dynamics theory through the study of complex systems.

237. **COULSON R. N. 1980.** Chapter 5. Population Dynamics. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Admin. Tech. Bull. 1631. p. 71-105. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, SAMPLING, OVIPOSITION, EMERGENCE Southern pine beetle populations within trees, infestations, and forests are discussed. Individual tree dynamics include colonization processes including attack, gallery construction and oviposition and resource use. Reemergence, emergence and survival of within-tree brood life stages are discussed. Southern pine beetle populations in infestations include patterns of spot growth, allocation of adults, between-tree survival and dispersal. Host dynamics are presented in the context of southern pine beetle dynamics.

238. **COULSON R. N., FARGO W. S., EDSON L. J., PULLEY P. E., BUNTING A. M. 1979.** Procedural guide for conducting field investigations on the population dynamics of the southern pine beetle. Tex. Agric. Exp. Stn. MP-1427, College Stn., Tex. 19 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, TRAPS AND CAGES, MISCELLANEOUS TECHNIQUES Presented is a comprehensive guide for investigating population dynamics of the southern pine beetle, *Dendroctonus frontalis*. The methodology of the tree geometry model-probability density function (TG-PDF) technique is discussed. Sampling and estimation procedures involving TAMBEETLE traps and bark disc sampling are discussed. Data requirements for estimation are presented. Management of field equipment and coordination of personnel to facilitate sampling procedures are described. Laboratory processing of field-collected data is discussed.

239. **COULSON R. N., FARGO W. S., PULLEY P. E., FOLTZ J. L., POPE D. N., RICHERSON J. V., PAYNE T. L. 1978.** Evaluation of the reemergence process of parent adult *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 110:475-486. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, LIFE HISTORY-GENERAL, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS, BEHAVIORAL CHEMICALS Models for reemergence of attacking adult southern pine beetle are developed from trapping data and bark samples. An estimated 97% of the attacking adult population reemerged, with peak reemergence occurring shortly after peak attack. The process

took 16-20 days overall. Laboratory bioassays showed reemerged parent adults responded to behavioral chemicals responsible for mass aggregation. The potential role of reemerged parent adults in population dynamics is discussed.

240. **COULSON R. N., FARGO W. S., PULLEY P. E., POPE D. N., FOLTZ J. L., BUNTING A. M.** 1979. Spatial and temporal patterns of emergence for within-tree populations of *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 111:273-287. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, EMERGENCE, TRAPS AND CAGES, MODELING Spatial and temporal patterns of adult *Dendroctonus frontalis* emergence from host trees are described using three and five parameter models. Temporal emergence patterns were similar for all heights, allowing emergence to be described as an average process for the whole tree. Peak emergence occurred on day seven of a 27 day process time span. Cumulative sex ratios were 1:1 with no difference in spatial or temporal patterns of emergence between sexes.

241. **COULSON R. N., FELDMAN R. M., FARGO W. S., SHARPE P. J. H., CURRY G. L., PULLEY P. E.** 1979. Evaluating suppression tactics for *Dendroctonus frontalis* in infestations. *In*, Evaluating Control Tactics for the Southern Pine Beetle-Symp. Proc. Jan 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 27-44. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TRAPS AND CAGES, STATISTICAL METHODS, MODELING, POPULATION DYNAMICS, CONTROL-GENERAL Three aspects involved in evaluating suppression tactics for *Dendroctonus frontalis* are presented as follows: 1) a protocol for evaluating treatment efficacy; 2) an application of the TAMBEETLE MODEL of *D. frontalis* population dynamics for evaluating treatment efficacy; and 3) a procedural outline for conducting field experiments to evaluate results of simulated treatment strategies. A step-by-step approach to evaluation of treatment procedures is discussed. Three treatment tactics of the TAMBEETLE MODEL are simulated and compared. The outline of procedures for conducting field experiments includes sampling and estimation technology, procedures for collection of data, and laboratory processing of field data.

242. **COULSON R. N., FOLTZ J. L., MAYYASI A. M., HAIN F. P.** 1975. Quantitative evaluation of frontalure and cacodylic acid treatment effects on within-tree populations of the southern pine beetle. J. Econ. Entomol. 68:671-678. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, PUPAE, ADULT, POPULATION DYNAMICS, BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-CHEMICAL. A life table approach was used to compare population dynamics of southern pine beetle attacking trees baited with frontalure, treated with cacodylic acid, and untreated controls. Cacodylic acid reduced attack density, decreased survival between egg-larva and larva-pupa-callow adult stages, suffered a greater total generation mortality, and had a reduced generation increase ratio compared to frontalure treated and control trees. No population dynamics differences were found between frontalure treated and control trees.

243. **COULSON R. N., HAIN F. P., FOLTZ J. L., MAYYASI A. M.** 1975. Techniques for sampling the dynamics of southern pine beetle populations. Tex. Agric. Exp. Stn. MP-1185, College Stn., Tex. 18 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING, MISCELLANEOUS TECHNIQUES, AGGREGATION, ECOLOGICAL DISTRIBUTION Procedures used to develop within-tree, within-infestation, and area-wide estimates of southern pine beetle life stages are presented including intensive, extensive, and proportional sampling schemes.

244. **COULSON R. N., HAIN F. P., PAYNE T. L.** 1974. Radial growth characteristics and stand density of loblolly pine in relation to the occurrence of the southern pine beetle. Environ. Entomol. 3:425-428. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, DISTRIBUTION, HOST SELECTION, HOST RESISTANCE, CONTROL-BIOLOGICAL, SURVEY AND DETECTION Reduced radial growth (annual increment) and high stand density (basal area) are associated with the incidence of southern pine beetle infestation in southeast Texas. The close spacing of trees appears to enhance growth of the infestations.

245. **COULSON R. N., LEUSCHNER W. A., FOLTZ J. L., PULLEY P. E., HAIN F. P., PAYNE T. L.** 1980. Approach to research and forest management for southern pine beetle control. Chapter 14, *In*, New Technology of Pest Control. C. B. Huffaker, Ed., John Wiley and Sons, N.Y. p. 449-469. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Monochamus titillator*). EGG, LARVAE, PUPAE, ADULT, POPULATION DYNAMICS, ECONOMICS, STATISTICAL METHODS, MODELING, INTEGRATED PEST MANAGEMENT, IMPACT, SAMPLING The authors discuss the history and structure of the Integrated Pest Management Program with special reference to the Expanded Southern Pine Beetle Research and Applications Program. The concept of insect impact and its ecological, economic, and philosophical implications is discussed from the standpoint of southern pine beetle damage to forested ecosystems. Database accumulation, data-file management, functional descriptions and within-spot sampling methodologies, and descriptions of within-tree population processes are component activities associated with the development of a population dynamics model and the development of quantitative estimation procedures.

246. **COULSON R. N., MAYYASI A. M., FOLTZ J. L., HAIN F. P.** 1976a. Interspecific competition between *Monochamus titillator* and *Dendroctonus frontalis*. Environ. Entomol. 5:235-247. (COLEOPTERA: CERAMBYCIDAE; *Monochamus titillator*. COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMPETITION, MODELING Interspecific competition was hypothesized to exist between *Dendroctonus frontalis* and *Monochamus titillator*. The presence of *M. titillator* may exert both interference and exploitation competition on southern pine beetle. The process of competition is substantiated by examining the within-sample distribution and by quantitatively defining the influence of *M. titillator* on mortality and survivorship of *D. frontalis*.

247. **COULSON R. N., MAYYASI A. M., FOLTZ J. L., HAIN F. P., MARTIN W. C.** 1976b. Resource utilization by the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 108:353-362. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, ADULT, HOST SELECTION, STATISTICAL METHODS The pattern of resource utilization as determined by the distribution of attacking adults along the infested bole and the gallery length (thus eggs) per unit area indicates a density dependent compensation resulting in a uniform amount of food and space per individual.

248. **COULSON R. N., MAYYASI A. M., FOLTZ J. L., PULLEY P. E.** 1976. Production flow system evaluation of within-tree populations of *Dendroctonus frontalis* (Coleoptera: Scolytidae). Environ. Entomol. 5:375-387. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING, MISCELLANEOUS TECHNIQUES Application of production flow system methods to modeling of *Dendroctonus frontalis* life stages is used as an alternative to a life table format. Transition probabilities between life stages for three years of study are included.

249. **COULSON R. N., OLIVERIA F. L., PAYNE T. L., HOUSEWEART M. W.** 1973a. Variables associated with use of frontalure and cacodylic acid in suppression of the southern pine beetle. 2. Brood reduction in trees treated with cacodylic acid. J. Econ. Entomol. 66:897-899. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL The manipulation of southern pine beetle populations using frontalure in conjunction with cacodylic acid treated trees is influenced by several variables including: size of the original infestation, stage of brood development in the originally attacked trees, tree size in the original infestation, the number of trees baited with frontalure, and the number of treated trees.

250. **COULSON R. N., OLIVERIA F. L., PAYNE T. L., HOUSEWEART M. W.** 1973b. Variables associated with use of frontalure and cacodylic acid in suppression of the southern pine beetle. I. Factors influencing manipulation to prescribed trap trees. J. Econ. Entomol. 66:893-896. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, AGGREGATION, DISTRIBUTION, BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL, STATISTICAL METHODS Variables associated with cacodylic acid treated trees include size of the infestation, stage of brood, tree size and number of trees treated.

251. **COULSON R. N., PAYNE T. L., COSTER J. E., HOUSEWEART M. W.** 1972. The southern pine beetle *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae) 1961-1971. Tex. For. Serv. Publ. 108. 38 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, PREDATOR, PARASITES, ATTRACTANTS, HOST SELECTION, CONTROL-GENERAL, SURVEY AND DETECTION, ECONOMICS, IMPACT, REVIEW, TAXONOMY This publication is a review which condenses reports on southern pine beetle research from the period 1961-1971. Research topics covered include: beetle development, parasites, predators, host and site, olfactory behavior, attractant compounds, olfactory perception, beetle suppression, survey and detection, taxonomic aspects, and economic aspects.

252. **COULSON R. N., POPE D. N., GAGNE J. A., FARGO W. S., PULLEY P. E., EDSON L. J., WAGNER T. L.** 1980. Impact of foraging by *Monochamus titillator* on within-tree populations of *Dendroctonus frontalis*. Entomophaga 25:155-170. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMPETITION, POPULATION DYNAMICS Pine sawyers competed with southern pine beetles for the pine resources.

253. **COULSON R. N., PULLEY P. E., EDSON L. J.** 1979. Sampling considerations for evaluating the effects of mortality agents on bark beetles. *In*, The Role of Insectivorous Birds in For. Ecosystems., Dickson, J. G., Conner, R. N., Fleet, R. R., Kroll, J. C., and Jackson, J. A., Eds. Acad. Press, Inc., N.Y. p. 53-67. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Monochamus* spp.). COMPETITION, PREDATOR, PARASITES, POPULATION DYNAMICS, RADIOGRAPHY, STATISTICAL METHODS The basic requirements for judging the effects of mortality agents on bark beetle populations are examined. Sampling the populations of both the host insect and mortality agents is described. Special attention is paid to the topological procedure for multiple samples. An in-depth discussion of interspecific competition between *Dendroctonus frontalis* and *Monochamus titillator* is included.

254. **COULSON R. N., PULLEY P. E., FOLTZ J. L., MARTIN W. C.** 1976. Procedural guide for quantitatively sampling within-tree populations of *Dendroctonus frontalis*. Tex. Agric. Exp. Stn. MP-1267, College Stn., Tex. 29 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MISCELLANEOUS TECHNIQUES, SAMPLING Procedures for estimating within-tree populations of *Dendroctonus frontalis* are presented. Data collection is briefly outlined. Estimations of host tree surface area and insect density are presented. Sampling plans are discussed that allow the user freedom to design plans comparable to financial resources and precision desired. Statistical tables and stepwise organization of calculations are presented.

255. **COULSON R. N., PULLEY P. E., FOLTZ J. L., MARTIN W. C., KELLEY C. L.** 1977. Survival models for within-tree populations of *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 109:1071-1077. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING, EMERGENCE, EGG, ADULT Mathematical models of southern pine beetle survivorship for generations (adult to adult) and egg to adult are developed as a function of height on the infested bole of attacked trees.

256. **COULSON R. N., PULLEY P. E., POPE D. N., FARGO W. S., EDSON L. J.** 1980. Continuous population estimates for *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae) occurring in infestations. Res. Popul. Ecol. 22:117-135. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, STATISTICAL METHODS, MODELING The pattern of spot growth exhibited by the southern pine beetle presents unique problems in quantitative population estimates. The processes of attack, oviposition, reemergence, survivorship, and emergence which each last several days duration have been described mathematically. A procedure was developed to enable quantitative estimation procedures for within-tree populations to be used in combination with mathematical models for life processes to produce a daily estimate. These estimates were summarized for all trees in the spot for the duration of the infestation.

257. **COULSON R. N., PULLEY P. E., POPE D. N., FARGO W. S., GAGNE J. A., KELLEY C. L.** 1980. Estimation of survival and allocation of adult southern pine beetles between trees during the development of an infestation. *In*: Proc. Second IUFRO Conf. on Dispersal of Forest Insects: Evaluation, Theory, and Management Implications, A. A. Berryman and L. Safranyik, Eds. p. 194-212. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, ECOLOGICAL DISTRIBUTION, DISTRIBUTION During the process of a developing infestation, the source of the colonizing bark beetles are determined. Percentage survival and emerging and reemerging bark beetles are tallied.

258. **COVINGTON C. C.** 1969. Laboratory rearing of the southern pine beetle, *Dendroctonus frontalis* Zimmerman, with emphasis on the production of virgin females. M. For. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 36 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, ADULT, EMERGENCE, TRAPS AND CAGES, REARING, MISCELLANEOUS TECHNIQUES Two methods were used to determine the earliest time of mating of *Dendroctonus frontalis* and a technique is described for rearing virgin females. Five consecutive laboratory generations were reared using a vial-confinement isolation technique.

259. **COYNE J. F.** 1953. Destructive insects of southern pine. Forest and People 4(1):18-20. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, REVIEW Reviews southern pine beetle impact in the southeastern United States in 1950-1951. Control recommendations include felling and salvaging infested timber. A generalized life history is included.

260. **COYNE J. F., CRITCHFIELD W. B.** 1974. Identity and terpene composition of Honduran pines attacked by the bark beetle *Dendroctonus frontalis* (Scolytidae). Turrialba 24:327-331. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE Three tree species (*Pinus oocarpa*, *P. caribaea* var. *hondurensis*, and *P. tenuifolia*) were identified as tree hosts for the southern pine beetle (*Dendroctonus frontalis*) in Honduras from 1963 to 1966. A study of host monoterpenes provided criteria for separating the tree species but no difference was observed between check trees and supposedly beetle-resistant trees.

261. **COYNE J. F., HELLER R. C., BEAN J. L.** 1954. Aerial survey methods used in combating a recent epidemic of the southern pine beetle. (Abstract). Assoc. South. Agric. Worker's Proc. 51:98-99. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Aerial surveys were used to detect southern pine beetle in Mississippi in 1952.

262. **COYNE J. F., LOTT L. H.** 1976. Toxicity of substances in pine oleoresin to southern pine beetles. J. Ga. Entomol. Soc. 11:301-305. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST RESISTANCE Monoterpenes of both loblolly and shortleaf pines were bioassayed against field-collected populations of the southern pine beetle (*Dendroctonus frontalis*) for toxicity studies. Limonene compounds were the most toxic and contributed to host-tree resistance against beetle attack. A table of tested compounds along with both LD_{50} and LT_{50} of each is included.

263. **CRAIGHEAD F. C.** 1926a. The Dendroctonus problems. J. For. 23:340-354. (COLEOPTERA: SCOLYTIDAE;

Dendroctonus frontalis, *Dendroctonus brevicomis*, *Dendroctonus piceaperda*, *Dendroctonus ponderosae*). LIFE HISTORY-GENERAL, CONTROL-GENERAL, ECONOMICS, IMPACT Four species of bark beetles (western pine beetle, black hills beetle, mountain pine beetle, and southern pine beetle) are discussed in light of their damages, habits, controls tactics, and future investigations. Craighead defines the epidemic and endemic status of the *Dendroctonus* problem. The phenomenon of *Dendroctonus* beetles as silvicultural agents is discussed.

264. **CRAIGHEAD F. C.** 1925b. Bark beetle epidemics and rainfall deficiency. J. Econ. Entomol. 18:577-584. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, WEATHER RELATIONSHIPS Bark beetle epidemics were related to rainfall deficiency.

265. **CRAIGHEAD F. C.** 1928. Interrelation of tree-killing bark beetles (*Dendroctonus*) and blue stains. J. For. 26:886-887. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMMENSALISM AND SYMBIOSIS The relationship between bark beetles and various blue-stain fungi is discussed. The probability that the insect and blue-stain together hasten tree death is proposed.

266. **CRAIGHEAD F. C.** 1935. A naval stores handbook dealing with the production of pine gum or oleoresin. USDA Misc. Publ. No. 209. p. 134-135. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL Briefly describes life history of *Dendroctonus frontalis*.

267. **CRAIGHEAD F. C.** 1941. The influence of insects on the development of forest protection and forest management. Annu. Rep. Smithson. Inst. p. 367-392. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CULTURAL, FIRE Forest insect relationships in relation to scenic and protection values, bark beetle control, and protection through management are presented.

268. **CRAIGHEAD F. C.** 1950. Insect enemies of eastern forests. USDA Misc. Publ. No. 657. p. 46-50, 315-318. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL, FIRE, LIGHTNING Describes life history of the southern pine beetle; outlines general control measures. Preventative measures suggested included mixing hardwoods and pines, preventing fires, checking pines struck by lightning, and checking for southern pine beetle-infested pines during droughts.

269. **CRAIGHEAD F. C., GRAHAM S. A., EVENDEN J. C. AND OTHERS.** 1927. The relation of insects to slash disposal. USDA Dep. Circ. 411. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips calligraphus*, *Ips avulsus*, *Ips grandicollis*). IMPACT Slash is not a problem in southern pine beetle areas.

270. **CRAIGHEAD F. C., ST. GEORGE R. A.** 1928. Some effects of fire and insect attack on shortleaf pine. For. Worker 4(2):11,12. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Fire and insect attacks are detrimental to shortleaf pine and must be considered in management plans.

271. **CRAIGHEAD F. C., ST. GEORGE R. A.** 1930. A new technique in tree medication for the control of bark beetles. Science 122:433-435. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Chemicals were injected into shortleaf pine for control of *Dendroctonus frontalis*. Chemical treatment was moderately effective; chemicals tested included potassium cyanide, sodium arsenite, sodium fluoride, hydrocyanic acid and others.

272. **CRAIGHEAD F. C., ST. GEORGE R. A.** 1938. Experimental work with the introduction of chemicals into the sap stream of trees for the control of insects. J. For. 36:26-34. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CHEMICAL Experimental work with the introduction of chemicals into the sap stream of trees for the control of insects is presented. Methods and techniques are discussed. Specific chemicals tested for control are presented. A comparison of old and new methods is discussed.

273. **CRAWFORD O. R.** 1963. New approach to fighting forest pests. For. Farmer 22(10):8-9. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW Research and funding of the southern pine beetle problem is discussed. A breakdown of where research money is supplied and who is using it is presented. Pheromone attraction is briefly discussed.

274. **CRAWFORD O. R.** 1967. More known about southern pine-bark beetle. Pulpwood Annu. p. 81-83. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). LIFE HISTORY-GENERAL, BEHAVIORAL CHEMICALS, REVIEW Crawford, of the Southern Forest Research Institute, summarizes impact and distribution of the southern pine beetle. Principal achievements included pheromone chemical analysis and beetle development.

275. **CRISP C. E., HERTEL G. D., BUFFAM P. E., WILLIAMS C. B. JR.** 1981. Field evaluation of phloem-mobile acephate for suppression of southern pine beetle. USDA For. Serv. Pacific Southwest For. and Range Exp. Stn., Res. Note PSW-352. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Aerially-applied acephate did not translocate from the foliage to the phloem when sprayed in October at the level of 1.1 to 2.3 kg./185 l/hectare.

276. **CROSS E. A., MOSER J. C.** 1971. Taxonomy and biology of some Pyemotidae: (Acarina: Tarsonemidae) inhabiting bark beetle galleries in North American conifers. Acarologia. 13(1):47-64. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis* ACARINA: TARSONEMIDAE; PYEMOTIDAE). ECOLOGICAL DISTRIBUTION, TAXONOMY, MITES Three species of mites (one parasitic) associated with southern pine bark beetles are described, with notes on their biologies.

277. **CURRY G. L., FELDMAN R. M., SHARPE P. J. H.,** 1978. A stochastic model of a temperature dependent population. Theor. Pop. Biol. 13:197-213. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). MODELING The stochastic temperature dependent model may be used for *Dendroctonus* spp.

278. **DANIELS R. F., LEUSCHNER W. A., BURKHART H. E.** 1976. Modeling the impact of the southern pine beetle. Va. J. Sci. (Abst.) 27:32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, ECONOMICS, IMPACT, MODELING Various models depicting insect-host relationships are discussed. Models described include the Potential Benefits Analysis Program (PBAP), the frontalis simulator (FRONSIM) and the PTAEDA model.

279. **DANIELS R. F., LEUSCHNER W. A., ZARNOCH S. J., BURKHART H. E., HICKS R. R.** 1979. A method for estimating the probability of southern pine beetle outbreaks. For. Sci. 25:265-269. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST RESISTANCE, CONTROL-CULTURAL, HAZARD/RISK RATING Using site, stand, and/or insect population data, a method is presented for estimating a continuous measure of southern pine beetle incidence. The model, estimation procedures and some calculations are given. Risk and hazard rating are also discussed.

280. **DEMARS C. J. JR.** 1980. Managing tree mortality location data with a desktop minicomputer. Proc. Symp. Remote Sensing for Natural Resources. *In*, International View of Problems, Promises, and Accomplishments. Moscow, Idaho. Sept. 10-14, 1979. p. 69-77. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The logistics and data management problems for tree mortality location are presented.

281. **DEMARS C. J., HAIN F. P.** 1980. Bark beetle dispersal related to patterns of tree mortality and wind. *In*, Proc. Second IUFRO Conf. on Dispersal For. Insects.: Evaluation, Theory and Manage. Implications, A. A. Berryman and L. Safranyik, Eds., Sandpoint, ID., Aug. 1979. p. 66-78. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus*

ponderosae). WEATHER RELATIONSHIPS, ECOLOGICAL DISTRIBUTION, HOST SELECTION Bark beetle dispersal is influenced by tree mortality and wind. These factors influence pheromone dispersal and distribution of the beetles.

282. **DEMARS C. J., HAIN F. P., SLAUGHTER G. W.** 1979. Distribution and abundance of photo-detected tree mortality over time. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc., Jan 30-Feb. 1, 1979. Many., La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 63-74. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, STATISTICAL METHODS During the summer and fall of 1976 and the spring of 1977, an 8568-acre tract in North Carolina was flown over and infrared transparencies were taken at 30-day intervals. From these transparencies tree mortality could be detected and counted. Significant values were obtained for contingency table analysis in equal size classes. Relationships of tree mortality, abundance and frequency to stand composition suggests a logistic growth equation (not shown to be statistically significant).

283. **DEMARS C. J., SLAUGHTER G. W., GREENE L. E., GHENT J. H.** 1982. Mapping pine mortality by aerial photography, Umstead State Park, North Carolina. USDA For. Serv. Res. Pap. PSW-168. 14 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Pine beetle mortality was detected and mapped using aerial photography.

284. **DICKENS J. C.** 1977. Olfactory perception of pheromones and host volatiles by the southern pine beetle, *Dendroctonus frontalis* Zimmermann (Coleoptera: Scolytidae). Ph. D. Diss., Tex. A&M Univ., College Station, Tex. 85 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS, BEHAVIORAL CHEMICALS, MORPHOLOGY AND PHYSIOLOGY Electroantennograms were used to show degrees of sensitivity and specificity over a wide range of pheromones and host volatiles. Host odors had a higher threshold for significant response than pheromones. There were differences observed in responses between sexes.

285. **DICKENS J. C.** 1978. Electrophysiological investigations of olfaction in bark beetles. Bull. Soc. Entomol. Suisse 52:203-216. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus pseudotsugae*, *Scolytus scolytus*, *Ips pini*, *Ips typographus*, *Ips calligraphus*). BEHAVIORAL CHEMICALS, ATTRACTANTS, MORPHOLOGY AND PHYSIOLOGY, BEHAVIOR Olfactory receptors of different beetles show degrees of sensitivity and specificity over a wide range of pheromone or host odors present. Host odors tend to have a higher threshold for significant olfactory response than pheromones. The study showed chiral specificity of the olfactory acceptors for several pheromones and one host odor. The best correlation between olfactory input and insect behavior is probably the recording of motor output (muscle potential).

286. **DICKENS J. C., PAYNE T. L.** 1977. Bark beetle olfaction: Pheromone receptor system in *Dendroctonus frontalis*. J. Insect Physiol. 23:481-489. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, MORPHOLOGY AND PHYSIOLOGY, MISCELLANEOUS TECHNIQUES, BEHAVIOR Techniques involving differential adaptation of antennal olfactory acceptors and electroantennograms (EAG) were used to show acceptor populations for pheromones and host compounds. A larger percentage of acceptors were occupied by the oxygen containing pheromones than hydrocarbon host tree terpenes. Pheromones were more commonly perceived by the opposite sex. An in-depth presentation of the sexual differences in olfaction is presented.

287. **DICKENS J. C., PAYNE T. L.** 1978a. Olfactory-induced muscle potentials in *Dendroctonus frontalis*: Effects of *trans*-verbenol and verbenone. Experientia 34:463-464. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, MORPHOLOGY AND PHYSIOLOGY *Dendroctonus frontalis* antennal muscle movement potentials were induced by stimulation with frontalin and were recorded with an electroantennogram. Beetle produced pheromones (i.e. verbenone and *trans*-verbenol) were found to decrease the muscle activity started by frontalin.

288. **DICKENS J. C., PAYNE T. L.** 1978b. Structure and function of the sensilla on the antennal club of the southern pine beetle, *Dendroctonus frontalis* (Zimmerman) [*sic*] (Coleoptera: Scolytidae). Int. J. Insect Morphol. Embryol. 7:251-265. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MORPHOLOGY AND PHYSIOLOGY Four types of sensilla occur on the antennal club of *Dendroctonus frontalis*. They are 1) sensilla busiconica, 2) trichodea II, 3) trichodea III, and 4) fluted sensilla. The morphologies of these are discussed.

289. **DILLON E. S., DILLON L. S.** 1961. Genus IV. *Dendroctonus* Erichson. A manual of common beetles of eastern North America. Row, Peterson and Co., Elmsford, N. Y. p. 801,808. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT Describes the adult *Dendroctonus frontalis*.

290. **DIX M. E., FRANKLIN R. T.** 1974. Inter- and intraspecific encounters of southern pine beetle parasites under field conditions. Environ. Entomol. 3:131-134. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. HYMENOPTERA: *Heydenia unica*, *Eurytoma* spp.). OVIPOSITION, FECUNDITY, COMPETITION, PREDATOR, PARASITES, POPULATION DYNAMICS, MISCELLANEOUS TECHNIQUES The inter- and intraspecific aggressiveness of two species of hymenopterous parasites of *Dendroctonus frontalis* are presented. A high degree of aggressiveness may lower the reproductive efficiency of both the attacked and attacking insect.

291. **DIX M. E., FRANKLIN R. T.** 1977. Diel activity of *Thanasimus dubius*, a southern pine beetle predator. J. Ga. Entomol. Soc. 12:71-75. (COLEOPTERA: CLERIDAE; *Thanasimus dubius*. SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, BEHAVIOR Peak adult *T. dubius* activity occurs during the late afternoon and night.

292. **DIX M. E., FRANKLIN R. T.** 1978. Field biology of three hymenopterous parasitoids of the southern pine beetle. J. Ga. Entomol. Soc. 13:71-80. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. PTEROMALIDAE, *Cecidostiba dendroctoni*, EURYTOMIDAE, *Eurytoma* spp. EUPELMIDAE, *Eupelmus* spp.). PARASITES, ECOLOGICAL DISTRIBUTION, HOST SELECTION, CONTROL-BIOLOGICAL, BEHAVIOR A study of the biologies of three hymenopterous enemies of the southern pine beetle is presented. *Cecidostiba dendroctoni*, *Eurytoma* spp. and *Eupelmus* sp. compete with other hymenopterous parasitoids for dominance in the *Dendroctonus frontalis* parasitoid complex. Arrival times, diel activity and host searching processes were observed.

293. **DIX M. E., FRANKLIN R. T.** 1981. Observations on the behavior of the southern pine beetle parasite *Roptrocerus ecoptogastri* Ratz. (Hymenoptera: Torymidae). J. Ga. Entomol. Soc. 16(2):239-248. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. HYMENOPTERA: TORYMIDAE; *Roptrocerus ecoptogastri*). ADULT, OVIPOSITION, SEASONAL OCCURRENCE, BEHAVIOR, PARASITES Arrival times, diel activity, host searching processes, intraspecific encounters and male swarming behavior of *Roptrocerus ecoptogastri* were observed.

294. **DIXON J. C., OSGOOD E. A.** 1961. Southern pine beetle. A review of present knowledge. USDA For. Serv. Southeast. For. Exp. Stn., Stn. Pap. No. 128. 34 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, DISTRIBUTION, CONTROL-GENERAL, HOST SELECTION This review summarizes current knowledge of the southern pine beetle. Areas discussed include geographic distribution, description of life stages, life history, the normal characteristics of its attack, its symbiotic relationship with *Ceratocystis minor*, normal flight habits, its preference for weakened trees and felled logs, possible predisposers to attack (stand factors and individual tree factors), methods of beetle rearing, and attack inducement. Biological, physical and chemical control agents are also discussed.

295. **DIXON W. N.** 1977. Response of beneficial and associated insects of the southern pine beetle to beetle-infested trees and to behavioral chemicals. M. S. Thesis, Tex. A&M Univ., College Station, Tex. 127 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMPETITION, PATHOGENS, AGGREGATION, DISTRIBUTION, BEHAVIORAL CHEMICALS, COMMENSALISM AND SYMBIOSIS, PREDATOR, PARASITES More than 150 species of insects were attracted to southern pine beetle-infested trees. The sequence of arrival and spatial distribution of the insects was investigated as well as the role of bark beetle pheromones and host tree volatiles in attraction of these insects. Arrival of predators and parasites corresponded to the abundance of appropriate host life stages. Associates occurred in peak numbers in later stages of tree infestation.

296. **DIXON W. N., PAYNE T. L.** 1979a. Aggregation of *Thanasimus dubius* on trees under mass-attack by the southern pine beetle. Environ. Entomol. 8:178-181. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, PARASITES, ECOLOGICAL DISTRIBUTION, BEHAVIORAL CHEMICALS, FLIGHT The temporal and spatial distribution of southern pine beetle and its clerid predator, *Thanasimus dubius*, were similar on trees undergoing mass attacks by southern pine beetle. Arrival at the tree peaked for southern pine beetle on day three of the mass attack period and on day four for the clerids. Clerids showed a bimodal daily activity with a major peak at 1900 hours. Southern pine beetle activity showed a single peak at 1700 hours. Distribution on the bole was similar, with both species concentrated in the lower half of the infected bole (64% of responding beetles).

297. **DIXON W. N., PAYNE T. L.** 1979b. Sequence of arrival and spatial distribution of entomophagous and associate insects on southern pine beetle-infested trees. Tex. Agric. Exp. Stn. MP-1432, College Stn., Tex. 27 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMPETITION, PREDATOR, PARASITES, SEX-RATIOS, BEHAVIORAL CHEMICALS Temporal and spatial patterns of beneficial and associated insects of the southern pine beetle are discussed. Peak arrival of predators and parasites occurred when the life stages of the beetle were most appropriate for attack. It was noted that mycetophagus insects were trapped commonly on the lower bole while parasites were at the upper bole. Most others fell in the middle.

298. **DIXON W. N., PAYNE T. L.** 1980. Attraction of entomophagous and associate insects of the southern pine beetle to beetle- and host tree-produced volatiles. J. Ga. Entomol. Soc. 15:378-389. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMPETITION, PREDATOR, PARASITES, BEHAVIORAL CHEMICALS, ATTRACTANTS The effects of several southern pine beetle behavioral chemicals on 15 entomophagous and 13 associated insects were investigated. Various insects were collected in baited areas (chemical mixtures varied) and the attraction was noted. The results indicate that several (entomophagous and associated) insects were attracted by behavioral chemicals emitted by scolytid-infested trees.

299. **DOANE R. W., VAN DYKE E. C., CHAMBERLAIN W. J., BURKE H. E.** 1936. Forest insects. McGraw-Hill Book Co., Inc., New York. p. 78. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL A short description of the southern pine beetle life cycle, distribution, and habits.

300. **DOGGETT C. A.** 1971. Foliage coloration changes in loblolly pine during southern pine beetle attack. J. Econ. Entomol. 64:1298-1299. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, EMERGENCE, HOST RESISTANCE, MISCELLANEOUS TECHNIQUES, CONTROL-CHEMICAL Foliage changes were studied in southern pine beetle attacked trees. For a short while after attack the foliage remained green, then faded to yellow, then red, to a point where only a few needles remained on the tree. The timing of these changes had no correlation to beetle attack but varied with time of year.

301. **DOWNING G. L., CIESLA W. M., RAUSCHENBERGER J. L.** 1968. Southern and Southeastern States. USDA For. Serv. For. Insect and Dis. Conditions in the U. S., 1968. p. 27-28. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT Discusses significant increases in southern pine beetle activity throughout the southeastern United States.

302. **DOWNING G. L., WARD J. D., CIESLA W. M.** 1969. Southern and Southeastern States (R-8). USDA For. Serv. Insect Conditions in the U. S. 1969. p. 25-27. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp.). SURVEY AND DETECTION, REVIEW The southern pine beetle was reported in Texas, Tennessee, North Carolina, South Carolina, Louisiana, Arkansas, and Alabama in 1969.

303. **DRAKE L. E.** 1970. Removal of infested timber by commercial sales. *In*, Proc., Fifth For. Insect And Disease Work Conf., Atlanta., Ga. Feb 17-19, 1970. p. 152-156. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp.). ECONOMICS, IMPACT, WOOD UTILIZATION Methods of southern pine beetle control by means of infested tree removal are discussed. This system was practiced in North Carolina during a southern pine beetle epidemic in 1962.

304. **DRAKE L. E.** 1974. Control of insects affecting pine plantations. USDA For. Serv., Proc. Symp. Manage. of Young Pines, 1974, p. 28-32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL Controls for the southern pine beetle are summarized.

305. **DULL C. W.** 1980. Loran-C radio navigation systems as an aid to southern pine beetle surveys. USDA Comb. For. Pest Res. and Dev. Prog. Agric. Handb. No. 567. 15 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES Loran-C uses synchronized, pulsed signals from three or more Loran ground stations to obtain position fixes for aircraft. The difference in arrival time for the signals is a measure in distance from the receiver to each ground station. The Loran-C system enables the pilot and survey crew to resurvey the same areas with precision. Information for navigation includes: 1) known starting point for the survey, 2) selection of the chain group repetition interval for the survey area, and 3) selection of secondary stations. Loran-C navigation can be used for southern pine beetle surveys, field plot locations and others.

306. **DULL C. W.** 1982. Forest insect and disease conditions in the South, 1980. USDA For. Serv. State and Priv. For. Southeast. Area, For. Rep. SA-FR 17. 66 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT Southern pine beetles were most active in western South Carolina and central parts of Georgia, Alabama and Mississippi. Eastern Oklahoma had 30,000 board feet of timber killed. Acres by ownership by state are listed. Aerial detection is outlined for each state. Projects on southern pine beetles are summarized.

307. **DULL C. W., SWAIN K. M.** 1981. Southern pine beetle outbreak status, Oct. 1979-Sept. 1980. USDA For. Serv. Southeast. Area, SA-FB/P28. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The southwide status of the southern pine beetle is discussed.

308. **DZIADZIO M. F.** 1978. Factors related to tree survival after southern pine beetle attack. M. S. Thesis, N. C. State Univ., Raleigh, N. C. 71 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, HOST SELECTION, HOST RESISTANCE, HAZARD/RISK RATING Host and site factors were compared between Virginia pines which had survived southern pine beetle attack and Virginia pines which had succumbed. A comparison was made of flow characteristics and chemical composition of oleoresin collected from both groups of trees. There were no significant differences in site and micro-site between the survivors and the non-survivors with the exception of different levels of zinc and magnesium in the 0-15cm layer of soil.

309. **EBEL B. H., MERKEL E. P., KOWAL R. J.** 1964. Key to southern forest tree insects - based on damage symptoms. For.

Farmer manu. Ed. 23(7):32-40. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Dendroctonus valens, Ips avulsus, Ips calligraphus, Ips grandicollis*). SURVEY AND DETECTION A key to the southern forest tree insects based on their damage symptoms is presented. See also 21(4):72-75, 14(7):72-75, and 20(7):78-79.

310. **EBEL B. H., MERKEL E. P., KOWAL R. J.** 1971. Key to southern forest tree insects of the south. For. Farmer Manu. Ed. 30(7):96-102. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Dendroctonus valens, Ips avulsus, Ips calligraphus, Ips grandicollis*). SURVEY AND DETECTION, IMPACT A key to the southern forest insects by damage characteristics is presented.

311. **EBEL B. H., MERKEL E. P., KOWAL R. J.** 1975. Key to damage of southern forest trees by insects. For. Farmer 39(5):114-119. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). SURVEY AND DETECTION An identification key is provided showing both identification of adults and gallery patterns.

312. **EBEL B. H., MERKEL E. P., KOWAL R. J.** 1977. Key to damage of southern forest trees by insects. For. Prod. Dir. p. 144-149. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Dendroctonus valens, Ips avulsus, Ips calligraphus, Ips grandicollis*). SURVEY AND DETECTION Gives keys to damage of southern pines by the southern pine bark beetle complex.

313. **EBEL B. H., MERKEL E. P., KOWAL R. J.** 1980. Insect damage: Key to identification of southern forest pests. For. Farmer 23rd Manual Ed. 39(5):101-106. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Keys to forest insect pests, including the southern pine beetle are presented.

314. **FARES Y., GOESCHL J. D., SHARPE P. J. H.** 1980. Dynamics of bark beetle-fungus symbiosis I. Pine tree anatomy and fungus growth pattern. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc., Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 54-60. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Ceratocystis minor*). COMMENSALISM AND SYMBIOSIS, MORPHOLOGY AND PHYSIOLOGY The growth pattern of the fungus *Ceratocystis minor* was observed to spread through pine tissues after attack by the southern pine beetle (*Dendroctonus frontalis* Zimm.). The directional growth and mechanism of water blockage of the fungus is discussed.

315. **FARES Y., MAGNUSON C. E., DORAISWAMY P. C., SHARPE P. J. H.,** 1980. Dynamics of bark beetle-fungus symbiosis II. Pine tree drying model. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 61-74. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Ceratocystis minor*). COMMENSALISM AND SYMBIOSIS A simple model for tree drying following attack of southern pine beetle, *Dendroctonus frontalis* Zimm., is presented. Rate of drying is based upon environmental and tree physiological parameters. The model gives a time course description of tree drying related to brood development and beetle emergence.

316. **FARES Y., SHARPE P. J. H., MAGNUSON C. E.** 1980a. Pheromone dispersion in a forested ecosystem. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 75-93. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus ponderosae*). ATTRACTANTS, STATISTICAL METHODS, MODELING, MISCELLANEOUS TECHNIQUES, WEATHER RELATIONSHIPS A discussion of the theoretical concepts of pheromone dispersal in the forest ecosystem is presented. Emphasis is given to aggregation and flight patterns of the southern pine beetle (*Dendroctonus frontalis*) and mountain pine beetle (*Dendroctonus ponderosae*). A simple generic model, the Gaussian plume model, is presented. The influence of micrometeorological factors on pheromone dispersal is discussed. Application toward utilization of the model by forest management is explored.

317. **FARES Y., SHARPE P. J. H., MAGNUSON C. E.** 1980b. Pheromone dispersion in forests. J. Theor. Biol. 84:335-359. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, WEATHER RELATIONSHIPS, ATTRACTANTS A model was developed showing the influence of micrometeorological conditions on pheromone dispersal within a pine beetle population. Two species of beetles were studied (*Dendroctonus frontalis* and *D. ponderosae*) in two different geographic locations. Methods for pheromone concentration calculation are also discussed.

318. **FARGO W. S.** 1977. Temporal and spatial patterns of colonization, reemergence, and emergence of the southern pine beetle, *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae). M. S. Thesis, Tex. A&M Univ., College Station, Tex. 73 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, EMERGENCE, STATISTICAL METHODS, MODELING, SAMPLING Spatial and temporal distributions of attacking southern pine beetle, gallery length, reemergence, and emergence of callow adults were investigated. Density distributions of the four processes were similar also on the infested tree bole, with maximum densities encountered at the 3.5m and 5.0m intervals.

319. **FARGO W. S.** 1981. Factors influencing the growth of multiple-tree infestations by the southern pine beetle, *Dendroctonus frontalis* Zimmermann. Ph.D. Diss., Tex. A&M Univ., College Station, Tex. 77 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, ECOLOGICAL DISTRIBUTION, DISTRIBUTION Southern pine beetle spots increased due to emerging and reemerging adults, concentration of pheromones and host tree attractants, and host density.

320. **FARGO W. S., COULSON R. N., GAGNE J. A., FOLTZ J. L.** 1979. Correlation of southern pine beetle attack density, oviposition, and generation survival with host tree characteristics and preceeding beetle life stages within the host. Environ. Entomol. 8:624-628. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, OVIPOSITION, HOST RESISTANCE, MODELING Three population variables, attack density (ATTKD), egg density/female (EGFEM) and generation survival (GENS) were correlated with three sets of variables (1-Host Characteristics, 2-Host Growth Characteristics, and 3-southern pine beetle Life Stages variables), through stepwise regression. Diameter of the host was the only significantly correlated independent variable, but ATTKD and EGFEM were significantly correlated to EGFEM and GENS respectively. No linear seasonal effects were found.

321. **FARGO W. S., COULSON R. N., PULLEY P. E., POPE D. N., KELLEY C. L., FOLTZ J. L.** 1978. Spatial and temporal patterns of within-tree colonization by *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 110:1213-1232, 1376. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS, AGGREGATION, MODELING The within-tree colonization of loblolly pine by the southern pine beetle was investigated with regard to the establishment of attacking adults and the construction of egg galleries. The spatial and temporal sequence of attack and gallery construction was characterized at 1.5 m intervals along the infested bole. The modeling process consisted of a three parameter nonlinear function describing the data. Data collection began of the day of initial attack and continued for 14 consecutive days.

322. **FARGO W. S., WAGNER T. L., COULSON R. N., COVER J. D., MCAUDLE T., SCHOWALTER T. D.** 1982. Probability functions for components of the *Dendroctonus frontalis*-host tree population system and their potential use with population models. Soc. Popul. Ecol. 24:123-131. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, STATISTICAL METHODS Techniques described can be used to generate (starting) values in *Dendroctonus frontalis* population models.

323. **FATZINGER C. W., DIXON J. C. 1965.** Use of X-rays to detect southern pine beetles in shortleaf pine bark. J. For. 63:451-455. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, RADIOGRAPHY A method of sampling *Dendroctonus frontalis* within-bark samples by use of X-rays is dicussed. The relative accuracy of this method is approximately equal to that of dissection. The X-ray technique is faster and less expensive than dissection.

324. **FELDMAN R. M., CURRY G. L., COULSON R. N. 1980.** The use and structure of the TAMBEETLE spot dynamics model. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 20-29. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). OVIPOSITION, STATISTICAL METHODS, MODELING, MISCELLANEOUS TECHNIQUES A description of the TAMBEETLE spot dynamics model, a computerized, mathematical model of *Dendroctonus frontalis* infestations, is presented. Emphasis is given toward the conceptual ideas supporting the model and its use. Specific input parameters for the various needs are represented. The four major components (immature development and emergence, gallery construction and oviposition, adult reemergence, and adult attack/allocation) are discussed and validated.

325. **FELDMAN R. M., CURRY G. L., COULSON R. N. 1981.** A mathematical model of field population dynamics of the southern pine beetle, *Dendroctonus frontalis*. Ecol. Model. 13:261-281. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, POPULATION DYNAMICS, WEATHER RELATIONSHIPS A population dynamics model of *Dendroctonus frontalis* within an infestation was developed. A model response which closely follows actual field responses resulted from the inclusion of variable forest stand density and microclimate conditions. Several component submodels which describe individual life stage processes of the beetle were integrated into the model.

326. **FELDMAN R. M., WAGNER T. L., SHARPE P. J. H., GAGNE J. A., COULSON R. N. 1981.** Within-tree life process models of the southern pine beetle, *Dendroctonus frontalis*. Ecol. Model. 13:247-259. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, EMERGENCE Models of gallery construction, emergence and reemergence of the southern pine beetle are developed to use in a general population dynamics model. Upon testing of these models with field data, it was shown that these laboratory-derived models closely predict the timing and length of gallery, and the timing of emergence and reemergence in the field.

327. **FELT E. P. 1905.** Insects affecting park and woodland trees. N. Y. State Museum Memoirs VIII. 1:6-7. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, OUTBREAKS A discussion of the economic impacts of the southern pine beetle and other insects in the period of 1890-1905 is presented.

328. **FELT E. P. 1924.** Manual of tree and shrub insects. The Rural Manuals. L. H. Bailey, Ed., MacMillian Co., New York. p. 252-253. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, CONTROL-GENERAL, REVIEW A general review of southern pine beetle detection, distribution, habits, and control measures.

329. **FERGUSON P. C. 1977.** Utilization potential for pulp and paper of southern pine harvested from beetle-infested forests. M. S. Thesis, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 58 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Seventy-five trees were classified into six 'kill classes' according to the length of time the tree had been dead on the stump before harvested. Chips from each tree were individually cooled, yield determined, and hardsheets prepared. Regardless of length of time since death, no reduction in pulp yield was noted. Tearing resistance decreased rapidly following beetle attack. Tensile strength increased slightly for wood utilized after six months and then decreased gradually for wood used after 24 months.

330. **FINGER C. K. 1978.** The relative abundance and seasonal occurrence of parasites of the southern pine beetle, *Dendroctonus frontalis* Zimmerman, in Louisiana with descriptions of immature stages. M. S. Thesis, La. State Univ., Baton Rouge, La. 68 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Roptrocerus eccoptogastri*, *Coeloides pissodis*, *Dendrosoter sulcatus*, *Spathius pallidus*, *Heydenia unica*, *Dinotiscus dendroctoni*). OVIPOSITION, TRAPS AND CAGES, PARASITES In the two widely separated geographic regions sampled, *Roptrocerus eccoptogastri* was the most abundant hymenopterous parasite of the southern pine beetle. Parasites were more abundant in the mid-bole region of the tree. Trees with thicker bark had fewer parasites of those species that oviposit through the bark. *Roptrocerus eccoptogastri* and *Dinotiscus dendroctoni* populations were directly correlated with southern pine beetle density.

331. **FINGER C. K., GOYER R. A. 1978.** Description of the final instar larvae of selected parasites of *Dendroctonus frontalis* Zimmerman with a key to the adults. La. Acad. Sci. 41:48-56. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Coeloides pissodis*, *Dendrosoter sulcatus*, *Spathius pallidus*, *Heydenia unica*, *Dinotiscus dendroctoni*, *Roptrocerus eccoptogastri*). PREDATOR, PARASITES, TAXONOMY Final larval instars of six hymenopterous parasites of *Dendroctonus frontalis* are distinguished. These parasites are *Coeloides pissodis*, *Dendrosoter sulcatus*, and *Spathius pallidus* (Family Braconidae); *Heydenia unica*, *Dinotiscus dendroctoni* (Family Pteromalidae) and *Roptrocerus eccoptogastri* (Family Torymidae). A key to the adult parasites is included.

332. **FISKE W. F. 1908.** Notes on insect enemies of wood boring Coleoptera. Proc. Entomol. Soc. Wash. 9:23-27. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR Discusses *Thanasimus dubius* as a predator of *Dendroctonus frontalis* in general terms.

333. **FITZPATRICK G., NEEL W. W., LASHOMB J. H. 1979.** Emergence and survivorship of *Dendroctonus frontalis* from three species of insecticide-treated pines. J. Ga. Entomol. Soc. 14:19-23. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL The effects of three concentrates (0.5% 1.0% and 2.0%) of the organophosphate insecticide, chlorpyrifos, on emergence of the southern pine beetle, *Dendroctonus frontalis*, were analyzed and compared to that of 0.5% application of lindane on three species (*Pinus echinata*, *Pinus taeda* and *Pinus elliottii*) of standing, beetle infested trees. Results indicate a significantly decreased emergence rate in all three species of trees treated with chlorpyrifos than in those treated with lindane.

334. **FLAVELL T. H., BARRY P. J., WARD J. D., CLERKE W. H. 1970.** An evaluation of the effects of sub-zero temperatures on an epidemic southern pine beetle population in Nanthahala and Cherokee National Forests and the Great Smoky Mountains National Park Tennessee and North Carolina. USDA For. Serv. Rep No. 70-1-46. 13 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MISCELLANEOUS TECHNIQUES, WEATHER RELATIONSHIPS Sub-zero temperatures greatly reduced southern pine beetle populations.

335. **FLORENCE L. Z., KULHAVY D. L. 1981.** Genetic variation and population structure of the southern pine beetle, *Dendroctonus frontalis*. *In*, Applications of Genetics and Cytology in Insect Systematics and Evolution., M. W. Stock, Ed. Proc. Symp. Natl. Meeting of the Entomol. Soc. Am., Atlanta, Dec. 1-2; 1980. For., Wildl. and Range Exp. Stn., Univ. of Idaho, Moscow. p. 141-152. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). GENETICS Data from five electrophoretic gene loci revealed high levels of within-tree southern pine beetle genic variation and significant spatial and temporal differentiation between trees separated by only a few meters.

336. **FLORENCE L. Z., JOHNSON P. C., COSTER J. E. 1982.** Behavioral and genetic diversity during disperal: Analysis of polymorphic esterase locus in southern pine beetle, *Dendroctonus frontalis*. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). GENETICS Dispersal behavior of *D. frontalis* in response to frontalin indicates an exponential decrease in response with distance from the emergence site. Increased genetic diversity was concurrent with increased

dispersal distance from the source population.

337. **FOLTZ J. L.** 1979. Posttreatment tree mortality in southern pine beetle spots as a measure of treatment effectiveness. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 14-17. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING, CONTROL-GENERAL Posttreatment tree mortality, as a measure of efficacy of control treatments of the southern pine beetle, *Dendroctonus frontalis*, is discussed. The Chi test of independence of distribution, regression analysis, t-tests for comparing means, and the nonparametric Wilcoxon rank sum and signed rank tests are suggested as valid statistical tests useful in analyzing posttreatment tree mortality for individually treated spots. The suggestions given apply only to individual spots, and not to larger geographic regions.

338. **FOLTZ J. L., MAYYASI A. M., COULSON R. N., PULLEY P. E., MARTIN W. C.** 1976. Host-tree geometric models for use in southern pine beetle population studies. Environ. Entomol. 5:714-719. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, POPULATION DYNAMICS, STATISTICAL METHODS, MODELING Host-tree geometric models can provide an easy and inexpensive estimation of host-tree characteristics and habit occupied by bark beetles. This paper discussed three uses of the models for testing the hypothesis of southern pine beetle distribution, estimating absolute population numbers, and describing tree characteristics within population models.

339. **FOLTZ J. L., MAYYASI A. M., HAIN F. P., COULSON R. N., MARTIN W. C.** 1976. Egg-gallery length relationship and within-tree analyses for the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 108:341-352. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, POPULATION DYNAMICS, STATISTICAL METHODS The functional relationships between egg gallery length (GL) to infested bole height and egg density (E) are described for epidemic southern pine beetle populations in southeast Texas. The relationship, E = 1.59 GL, provides a reasonable estimate of E at all infested bole heights.

340. **FOLTZ J. L., PULLEY P. E., COULSON R. N., MARTIN W. C.** 1977. Procedural guide for estimating within-spot populations of *Dendroctonus frontalis*. Tex. Agric. Exp. Stn., College Station, Tex. MP-1316. 27 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, STATISTICAL METHODS, MISCELLANEOUS TECHNIQUES Two sampling procedures (one a random sample of trees within strata based on life stage; the other sampling of the largest diameter trees within the same strata) are presented for estimation of within-spot southern pine beetle populations. Tables are provided for setting confidence intervals on the estimates.

341. **FOLTZ J. L., PULLEY P. E., POPE D. N.** 1980. Evaluating the contribution of component processes in the dynamics of southern pine beetle infestations. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 109-118. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING, EMERGENCE A model is described for simulating the number of new attacks that occur through time in a defined geographic area. The relative effects of within-tree reproduction, parental reemergence, brood mortality, brood emergence, between-tree mortality, and migration on spot growth are presented. The numbers of newly emerged brood, reemerged parental females from within the infestation, and immigrant females from other infestations are summed to estimate attacking population during a given time period. Simulation of the model shows those parameters which lead to increasing, decreasing or stable population values.

342. **FOLWEILER A. D.** 1951. Southern pine bark beetle epidemics. Forests and People 1(3):10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). HOST SELECTION Briefly summarizes factors leading to bark beetle outbreaks, including moisture stress.

343. **FORBES R. D.** 1930. Timber growing and logging and turpentining practices in the southern pine region. USDA Tech. Bull. No. 204. p. 103. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*). LIFE HISTORY-GENERAL Briefly mentions southern pine beetle as a potential problem in pines grown for turpentine.

344. **FORD J. E.** 1951. A new danger for tree farmers. Res. and Farming 10(2):3-4. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL, SURVEY AND DETECTION, REVIEW, FIRE, LIGHTNING Reviews the southern pine beetle outbreaks in the southeastern United States; gives the life history of the southern pine beetle. Beetle damage is characterized, and causes of attack include dry weather, fire, lightning, and wind damage. Controls include cold winter temperatures, woodpeckers, benzene hexachloride, and maintaining healthy stands.

345. **FOSTER D.** 1982. A resource manager looks at integrated pest management and the southern pine beetle. *In*, Increasing forest productivity. Proc. 1981 Soc. Am. For. Natl. Meet., Orlando, Fla. p. 175-177. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). INTEGRATED PEST MANAGEMENT, REVIEW, TECHNOLOGY TRANSFER Foster defines IPM from an industrial point of view. Included is the idea of cooperation between agencies and technology transfer.

346. **FOSTER J. H.** 1912. Forest conditions in Louisiana. USDA For. Serv. Bull. 114. p. 34. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT Louisiana pine timber is susceptible to attack by the southern pine beetle, whose populations can increase radically under favorable conditions.

347. **FRANCKE-GROSMANN H.** 1965. Ein Symbioseorgan bei dem Borkenkafer *Dendroctonus frontalis* Zimm. (Coleoptera, Scolytidae). Kurze Originalmitteilungen 6:143. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMMENSALISM AND SYMBIOSIS The mycetangia of *Dendroctonus frontalis* is described.

348. **FRANCKE-GROSMANN H.** 1966. Uber symbiosen von xylo-mycetophagen und phloeophagen Scolytoidea mit holzbewohnenden Pilzen. Holz und Org. Internal. Symp. Berlin-Dahlem (1965) 1:503-522. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Dendroctonus mexicanus*, *Dendroctonus parallelocollis*, *Dendroctonus adjunctus*, *Ips acuminatus*, *Hylurgops palliatus*, *Hylastes ater*, *Hylastes cunicularius*. *Ceratocystis minor*). COMMENSALISM AND SYMBIOSIS, MORPHOLOGY AND PHYSIOLOGY Labels some bark-inhabiting insects that have mycetangia as phloeomycetophagous. Proposes *Ceratocystis minor* as the main fungus of *D. frontalis* mycetangia.

349. **FRANKLIN R. T.** 1967. A technique for studying the insect parasites of *Dendroctonus frontalis* and other bark beetles (Coleoptera: Scolytidae). J. Ga. Entomol. Soc. 2:43-44. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, REARING, MISCELLANEOUS TECHNIQUES Franklin discusses the possibility of using a gallon glass jar to study insect parasites of *Dendroctonus frontalis* Zimm. A small pine bolt, infested with southern pine beetles can then be put into the jar for observation. Suggestions on maintaining suitable moisture requirements are presented.

350. **FRANKLIN R. T.** 1969a. Hymenopterous parasites of the southern pine beetle in Georgia. J. Ga. Entomol. Soc. 4:119-122. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, PREDATOR, PARASITES, REARING Eight families and fifteen species of Hymenoptera, suspected of being parasites of the southern pine beetle, *Dendroctonus frontalis*, were studied through observation and rearing in field and laboratory tests. Parasitism was observed in six of the species on southern pine beetle larvae in naturally infested trees. Of these, four species were observed to be parasitic in laboratory tests of pine bolts infested with southern pine beetle. Habits, life history, and abundance of parasitic species are briefly presented.

351. **FRANKLIN R. T.** 1969b. Southern pine beetle influences on the pine-hardwood forest in the Georgia Piedmont. *In*, Proc. Tall Timbers Conf. Ecol. Animal Control by Habitat Manage. p. 117-125. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, EMERGENCE, ECONOMICS, IMPACT, MISCELLANEOUS TECHNIQUES Reviews the impact of the southern pine beetle on the pine-hardwood forest of the Georgia Piedmont. Patterns of response and attacks of southern pine beetle following baiting of pines with fresh cut bolts showed that with the proper pheromone concentrations and numbers of southern pine beetle adults, tree infestations can occur continuously. Franklin suggests the critical point in the beetle life history is the emergence of parent beetles and the later emergence of beetles from the same tree. Pheromone production drops during the winter; this has important control considerations.

352. **FRANKLIN R. T.** 1970a. Southern pine beetle population behavior. J. Ga. Entomol. Soc. 5:175-182. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, EMERGENCE, BEHAVIORAL CHEMICALS, ATTRACTANTS, BEHAVIOR Outbreaks of the southern pine beetle can develop from a single tree. An aggregating pheromone concentrates the population and assists in sustaining the infestations. Reemergent adults essentially double the time of pheromone production and number of attacks. Patterns of southern pine beetle infestations in stands are diagrammed.

353. **FRANKLIN R. T.** 1970b. Southern pine beetle population behavior. *In*, Proc. Fifth For. and Dis. Control Work Conf., Atlanta, Ga., Feb. 17-19, 1970, Div. For. Pest Control, Southeast. Area, State and Priv. For., USDA For. Serv. p. 119-129. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, EMERGENCE, BEHAVIORAL CHEMICALS, ATTRACTANTS, BEHAVIOR See Franklin (1970a).

354. **FRANKLIN R. T.** 1970c. Observations on the blue stain-southern pine beetle relationship. J. Ga. Entomol. Soc. 5:53-57. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Ceratocystis minor*). LARVAE, ADULT, FECUNDITY, VECTOR, COMMENSALISM AND SYMBIOSIS Franklin concluded that blue-stain fungi are probably detrimental to the survival of *Dendroctonus frontalis*.

355. **FRANKLIN R. T., GREEN H. J.** 1965. Observations on clerid predation of the southern pine beetle. J. Kans. Entomol. Soc. 38:202-203. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, HOST SELECTION, CONTROL-BIOLOGICAL Clerids were effective predators of the southern pine beetle.

356. **FRAZIER J. L., NEBEKER T. E., MIZELL R. F., CALVERT W. H.** 1981. Predatory behavior of the clerid beetle *Thanasimus dubius* (Coleoptera: Cleridae) on the southern pine beetle (Coleoptera: Scolytidae). Can. Entomol. 113:35-43. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, BEHAVIOR The clerid beetle, *T. dubius*, preyed on *D. frontalis*. Palps were most important in prey handling.

357. **FRIEND R. B.** 1942. Enemies of loblolly pine. Yale Univ. School For. Bull. 49 p. 143-146. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*. CERAMBYCIDAE; *Monochamus titillator*). CONTROL-CULTURAL Cultural controls and stand conditions for the southern pine beetle are briefly outlined.

358. **FRONK W. D.** 1947. The southern pine beetle: Its life history. Va. Agric. Exp. Stn. Tech. Bull. 108. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, EGG, LARVAE, PUPAE, ADULT The biology of *Dendroctonus frontalis* was investigated in field and laboratory experiments. Eggs, larvae, pupae, and adults were described. Head capsule measurements are given for the four larval instars. Periods of maximum emergence are presented. Average life span was 47 days. Optimum emergence of the southern pine beetle occurs between moisture loss of 19 to 28 percent.

359. **GAGNE J. A.** 1980. The effects of temperature on population processes of the southern pine beetle, *Dendroctonus frontalis* Zimmermann. Ph.D. Diss., Tex. A&M Univ., College Station, Tex. 181 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, PUPAE, ADULT, POPULATION DYNAMICS, REARING, STATISTICAL METHODS, MODELING, WEATHER RELATIONSHIPS The effects of temperature on development and mortality of the southern pine beetle were investigated. A model was developed to describe mathematically the effects of temperature on eggs, larvae, pupae, callow adults, reemerging adults, and the longevity of brood adults.

360. **GAGNE J. A., COULSON R. N., FOLTZ J. L., WAGNER T. L., EDSON L. J.** 1980. Attack and survival of *Dendroctonus frontalis* in relation to weather during three years in East Texas. Environ. Entomol. 9:222-229. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, EMERGENCE, WEATHER RELATIONSHIPS Seasonal trends in *Dendroctonus frontalis* population dynamics were examined for relation to temperature and rainfall. Survival of eggs to emerging beetles and survival of third and fourth instar larvae to pupae were associated with temperature (day-degree) and rainfall (proportion of infestation period when 0.6 cm. of rain fell per day). Both were negatively correlated with the weather indices.

361. **GAGNE J. A., SHARPE P. J. H., COULSON R. N., WAGNER T. L.** 1980. Modeling southern pine beetle reemergence and emergence as functions of temperature. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 30-39. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, PUPAE, ADULT, EMERGENCE, STATISTICAL METHODS, MODELING, WEATHER RELATIONSHIPS Before a comprehensive model of reemergence and emergence of the southern pine beetle, *Dendroctonus frontalis*, could be developed, a comprehensive data base had to be developed, and models glossing over temperature effects had to be modified. Here a two-component model is described showing reemergence and emergence related to temperature; the first component relates to temperature; the second looks at calendar time.

362. **GAGNE J. A., WAGNER T. L., PULLEY P. E., COVER J. D., COULSON R. N.** 1981. An analysis of estimators of trends in southern pine beetle populations. Environ. Entomol. 10:31-38. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EMERGENCE, SAMPLING, MODELING, STATISTICAL METHODS Two estimators (R and S) of population trends of *Dendroctonus frontalis* Zimm. were evaluated from samples of *Pinus taeda* infested in 1977. R, the brood increase ratio, denotes the number of brood beetles emerging per parent. S, within-tree survival, denotes the number of brood beetles emerging per egg. Descriptions of the statistical distributions of each estimator are examined. Tests of hypotheses are presented. Histograms are described using the Weibull distribution. Reliability of estimates was discussed.

362b **GAGNE, J. A., WAGNER T. L., SHARPE P. J. H., COULSON R. N., FARGO W. S.** 1982. Reemergence of *Dendroctonus frontalis* (Coleoptera: Scolytidae) at constant temperatures. Environ. Entomol. 11:1216-1222. (COLEOPTERA: Scolytidae; *Dendroctonus frontalis*). EMERGENCE, MODELING, REEMERGENCE The southern pine beetle reemerged between 12.5 and 33.5 degrees C. Adult residence time and constant temperature formed a backwards "J"-shaped curve. Adult residence time 12.5°C (46 days) and least at 27°C (12 days). About 90% of the beetles reemerged at temperatures between 12.5 and 30 degrees C. A two-component model; incorporating reemergence rates as a function of temperature and the reemerging population over physiological time, was developed.

363. **GAMMILL W. J.** 1978. An evaluation of chlorpyrifos used in combination with frontalure and *endo*-brevicomin for manipulation of southern pine beetle, *Dendroctonus frontalis* Zimmerman. M.S. Thesis, Miss. State Univ., Miss. State, Miss.

38 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TRAPS AND CAGES, BEHAVIORAL CHEMICALS, ATTRACTANTS, MISCELLANEOUS TECHNIQUES A slow release device for dispensing frontalure was developed using inexpensive, readily available materials. Loblolly pines were treated with a toxicant (chlorpyrifos), an attractant (frontalure), and an inhibitor (*endo*-brevicomin) in different combinations to evaluate their effectiveness in preventing southern pine beetle attack. Toxicant treated trees were protected for five months, and if also attractant treated, they were attacked at this time. Inhibition treatments did not appear to be effective in repelling southern pine beetles.

364. **GAMMILL W. J., FITZPATRICK G., NEEL W. W.** 1978. A dispenser for release of the aggregating pheromone of the southern pine beetle. J. Ga. Entomol. Soc. 13:95-97. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, TRAPS AND CAGES, MISCELLANEOUS TECHNIQUES An efficient, inexpensive dispenser for frontalure was described.

365. **GARA R. I.** 1966a. Results of research conducted on the southern pine beetle. Am. Pulpwood Assoc. p. 28-29. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, HOST SELECTION, HOST RESISTANCE, CONTROL-CHEMICAL, CONTROL-CULTURAL, REVIEW Gara introduces the concept of 'trap spots' for manipulation and control of southern pine beetles. The idea of a dispersal flight in search of breeding material and a concentration flight leading to colonization are discussed.

366. **GARA R. I.** 1966b. What we have learned from new research on the southern pine beetle. For. Farmer, March, 1966. p. 6-7,18-19. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, AGGREGATION, ATTRACTANTS, HOST SELECTION, CONTROL-CHEMICAL, REVIEW Discusses the role of the Southern Forest Research Institute and cooperative efforts with the Boyce Thompson Institute for investigating southern pine beetle outbreaks. 1965 investigations included southern pine beetle population dynamics and control tactics. The concept of manipulating the insect with attractants in 'trap-spots' was superior to 'trap-trees.' BHC with an oil or water carrier rendered trees immune to attack for up to two months.

367. **GARA R. I.** 1967a. A field olfactometer for studying the response of the southern pine beetle to attractants. J. Econ. Entomol. 60:1180-1181. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES A new field olfactometer for studying the response of *Dendroctonus frontalis* to attractants is described. The sleeve olfactometer serves as a bait trap since beetles attracted to the device ultimately fall into a series of jars for collection.

368. **GARA R. I.** 1967b. Studies on the attack behavior of the southern pine beetle. I. The spreading and collapse of outbreaks. Contrib. Boyce Thompson Inst. Plant Res. 23:349-354. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EMERGENCE, BEHAVIORAL CHEMICALS, ATTRACTANTS The influence of southern pine beetle brood emergence synchronization with active pheromone production within an infestation on dispersal of emerging southern pine beetle indicates that lack of synchronization results in dispersal of the brood out of the infestation, thus contributing to the collapse of the infestaion. Marking of emerging southern pine beetle with fluorescent powder and subsequent recapture at sleeve olfactometers around attacked trees in the vicinity of the infestation indicate dispersal capabilities of at least one mile.

369. **GARA R. I., COSTER J. E.** 1968. Studies on the attack behavior of the southern pine beetle. III. Sequence of tree infestation within stands. Contrib. Boyce Thompson Inst. 24:77-85. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus brevicomis, Dendroctonus ponderosae, Dendroctonus pseudotsugae*). POPULATION DYNAMICS, AGGREGATION, BEHAVIORAL CHEMICALS, HOST SELECTION, STAND CONDITIONS, ATTRACTANTS The shifting of mass attack from an initial stem to an adjacent stem is governed by the distance between the two stems. Stems closest to a source of attraction will usually be attacked next because of a higher level of olfactory stimuli that induce landing and boring behavior. Trees farther than 25 feet from a source of attraction are unlikely to be attacked in numbers sufficient for colonization.

370. **GARA R. I., VITÉ J. P., CRAMER H. H.** 1965. Manipulation of *Dendroctonus frontalis* by use of a population aggregating pheromone. Contrib. Boyce Thompson Inst. Plant Res. 23:55-66. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, FLIGHT, HOST SELECTION, TRAPS AND CAGES, BEHAVIORAL CHEMICALS Studies of southern pine beetle dispersal associated with the presence of aggregating pheromone suggest a two phase colonization consisting of: 1) focused aggregation on a single freshly attacked tree, and 2) mass aggregation in the general vicinity of the original attack, including landing on vertical objects regardless of their suitability as hosts. Experimentally induced attacks of selected trees coupled with destruction of the concentrated population is suggested as a potential control technique for use with aggregation pheromones once they are available.

371. **GARGIULLO P. M.** 1980. Effects of host density and bark thickness on the densities of parasites of the southern pine beetle. M. S. Thesis, Univ. Ga., Athens, Ga. 24 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Roptrocerus xylophagorum, Dendrosoter sulcatus, Heydenia unica, Coeloides pissodis, Cecidostiba dendroctoni, Spathius pallidus, Eurytoma tomica, Eurytoma cleri*). STATISTICAL METHODS, MODELING, PARASITES, SAMPLING Relative densities of parasites of the southern pine beetle are correlated with host density and bark thickness. All parasites except *Spathius pallidus* exhibited inverse density dependent responses to southern pine beetle densities. No parasite overcompensation was observed. All species' densities increased linearly with decreasing bark thickness .

372. **GARGIULLO P. M., BERISFORD C. W.** 1981. Effects of host density and bark thickness on the densities of parasites of the southern pine beetle. Environ. Entomol. 10:392-399. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. PTEROMALIDAE; *Rhopalicus* sp. TORYMIDAE; *Roptrocerus xylophagorum*). PARASITES, POPULATION DYNAMICS The effects of southern pine beetle density and tree bark thickness (BKTH) on eight hymenopterous parasites of *Dendroctonus frontalis* were studied. *Rhopalicus* sp. density showed a linear increase with southern pine beetle density and decreasing BKTH. *Roptrocerus xylophagorum* density was linearly related to southern pine beetle density and BKTH, and showed a rough correlation with southern pine beetle densities from spot to spot. *R. xylophagorum* showed a marked sensitivity to host density, and may be the most important parasite of southern pine beetle.

373. **GAUMER G. C.** 1967. Effects of phloem temperature and moisture content on survival of southern pine beetle broods. M. For. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 50 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, MISCELLANEOUS TECHNIQUES The effects of phloem moisture content and temperaure on development and survival of southern pine beetle broods were investigated. Moisture-temperature conditions were observed in standing green trees, a standing severed tree, and a standing infested tree. Laboratory experiments were designed which simulate field rearing conditions to determine marginal and lethal phloem moisture-temperature relationships for southern pine beetle brood.

374. **GAUMER G. C., GARA R. I.** 1967. Effects of phloem temperature and moisture content on development of the southern pine beetle. Contrib. Boyce Thompson Inst. Plant Res. 23:373-377. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LARVAE, PUPAE, EMERGENCE, HOST RESISTANCE, REARING, ECONOMICS, IMPACT, MISCELLANEOUS TECHNIQUES The optimum rearing environment for southern pine beetles from infested bolts ranges from 20 to 22 degrees Celsius and relative humidity of 50 to 60 percent. These conditions approach naturally occurring

infested-tree moisture content. After two weeks, bolts lose too much moisture to produce new brood; older larvae have already migrated into the bark.

375. **GEER S. F.** 1979. Effects of weather on flight of the southern pine beetle, *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae). M. S. Thesis, Stephen F. Austin State Univ., Nacogdoches. 89 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FLIGHT, WEATHER RELATIONSHIPS The greatest influence of weather on southern pine beetle daily flight activity occurred during the winter. Low flight activity was associated with low temperaure and low insolation. In the spring, flight was significantly correlated (inversely) with daily precipitation. During the fall, flight was correlated with relative humidity and insolation, while in the summer there was no correlation between flight and the four observed weather factors.

376. **GEER S. F., COSTER J. E., JOHNSON P. C.** 1981. Effects of weather on flight activity of southern pine beetle. J. Ga. Entomol. Soc. 16:272-282. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS, FLIGHT Beetle flight activity was measured in 0.56 hectare grids within four naturally occurring southern pine beetle infestations in East Texas. Observations of solar insolation (I), relative humidity (RH), precipitation (P), and temperature (T) were taken concurrent with flight information. The association of daily flight with weather factors was seasonally dependent. During the summer, flight was independent of weather conditions; in the fall, RH and I were correlated; during the winter, only P was not correlated with flight activity and spring flight was significantly correlated with daily P. It appears that during winter months, weather plays its greatest role in beetle flight activity. The greatest influence of weather on southern pine beetle daily flight activity occurred during the winter. Low flight activity was associated with low temperature and low insolation. In the spring, flight was significantly correlated (inversely) with daily precipitation. During the fall, flight was correlated with RH and insolation, while in the summer there was no correlation between flight and the four observed weather factors, due to the generally favorable conditions.

377. **GEILER H.** 1976. Praxis der inegrierten schadlingsbekampfung in agro-okosystemen. (Practical integrated pest control in agricultural ecosystems). Biol. Rundsch. 13:226-232. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus ponderosae, Dendroctonus frontalis, Dendroctonus brevicomis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL, ECONOMICS, IMPACT, REVIEW Integrated pest management is discussed.

378. **GENT J. A. JR.** 1977. The influence of site and stand factors on the migration habit of the southern pine beetle. M. S. Thesis, N. C. State Univ., Raleigh, N. C. 111 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, BEHAVIOR, STAND CONDITIONS, OUTBREAKS Site and stand characteristics were examined to determine possible factors responsible for migration of southern pine beetle from an infestation to an area nearby but separate from the infestation in which they emerged. Soil analysis revealed no significant differences between infestations and the 'skipped over area' except that phosphorus concentration of the B2 horizon was higher in the areas skipped over. This nutrient may have some connection with beetle migration.

379. **GEORGIA FORESTRY COMMISSION.** NO DATE. The susceptible forest in the Upper Piedmont. Ga. For. Comm. 1 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, HAZARD/RISK RATING One page fact sheet relating southern pine beetle attack to stand, soil and host tree characteristics. A hazard-rating model based on checking yes/no for stand, tree and soil characteristics is given. Cultural treatments recommended include favoring loblolly pine, intermediate cuttings, mixed pine-hardwood stands, and avoiding harvesting injuries.

380. **GEORGIA FORESTRY COMMISSION.** 1977. Decreasing southern pine beetle level trend continues in 1977. Ga. For. 30(4):4. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION A preliminary October survey of Georgia showed a decrease in southern pine beetle activity to the April level. Beetle activity escalated during the next three months. By July 1977 there were 1095 spots. Salvage operations resulted in the harvesting of 236,000 board feet of sawtimber and 4,402 cords of pulpwood.

381. **GEORGIA FORESTRY COMMISSION.** 1980. Status report, bark beetle infestations in Georgia. Ga. For. Comm. 14 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CULTURAL, SURVEY AND DETECTION, WOOD UTILIZATION, IMPACT Southern pine beetle activity continued in a downward trend since July of 1980. A total of 1,018,973 cords of beetle-killed wood had been salvaged. A total of 2,603 southern pine beetle spots were detected in September. Control is most effective in the winter. Maps are given for counties in Georgia reporting southern pine beetle, *Ips* and black turpentine beetle activity in September, 1980. Summaries by counties for infestations are given.

382. **GEORGIA FORESTRY COMMISSION.** 1981. Entomologists complete two county cut and leave project to control beetles. Ga. For. Comm., March. p. 8-9. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CULTURAL A project to determine the effectiveness of cut-and-leave was demonstrated in Greene and Taliaferro Counties of Georgia. Every spot that was cut in Greene County was picked up for salvage within one month. As beetle populations were declining no valid impact could be realized. A review of southern pine beetle biology is included.

383. **GERHART G. A., AHLER E. E.** 1949. Southern pine beetle control on Norris Reservoir lands. J. For. 47:636-639. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CHEMICAL, SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES The southern pine beetle killed a total of 231 acres of timber on a 16-mile course on Tennessee Valley Authority land in 1945. The characteristics of the infestation, including costs, techniques, and control measure effectiveness are included. Control measures included fell, pile and burn, pile and fell, limb and bucking up infested trees. Chemical treatments included orthodichlorobenzene and kerosene. Timely control action is recommended for TVA lands.

384. **GOEHRING C. B.** 1980. In-grade flexural properties of structural lumber harvested from a bark beetle infested southern pine forest. M. S. Thesis, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 100 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION An attempt was made to effectively measure the utilization potential of beetle-killed timber which is usually considered cull by visual stress grading methods. Two-by-six structural lumber was tested for actual strength and stiffness properties as outlined by ASTM standards. SPIB grading rules provide viable guides in establishing stress rated grades. However, a utilization potential exists for beetle-killed lumber in stress rated grade number three.

385. **GOLD H. J., MAWBY W. D., HAIN F. P.** 1979. A framework for modeling endemic-epidemic transitions in southern pine beetle. *In*, Population Dynamics For. Insects At Low Levels, Work Conf. Aug. 1979, N. C. State Univ., F. P. Hain, Ed. p. 27-32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, HOST SELECTION, MODELING A framework for modeling the population dynamics of the southern pine beetle, *Dendroctonus frontalis*, is presented based upon a hierarchy of four levels: individual tree, local neighborhood, stand, and large geographic region. The distinction is made between endemic and epidemic modes on an individual tree basis. Other levels are considered on the basis of which epidemic mode trees dominate respective levels.

386. **GOLD H. J., MAWBY W. D., HAIN F. P.** 1980. A modeling hierarchy for southern pine beetle. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc., Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 119-131.(COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, MISCELLANEOUS TECHNIQUES A description of the

overall hierarchial modeling framework as a basis for which methods are being developed for the studying of population levels of the southern pine beetle is given. All levels, from the individual tree to large geographical regions, are explored. Statistical methods for population studies are presented.

387. **GOLDEN M. S.** 1975. The use of small scale imagery for the location of pine infested by the southern pine beetle. Remote sensing of earth resources. Univ. Tennessee, Tullahoma, 3:353-359. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Color and color infrared imagery at 1:120,000 scale and color infrared imagery at 1:60,000 and 1:30,000 scales were used to located southern pine beetle spots. Using 80x magnification, clusters of two or more trees could be detected at 1:60,000 and clusters larger than 25 foot diameter on the 1:120,000 scale. A 1:30,000 scale could be used to distinguish between active and inactive spots. Color IR was superior to color for detection.

388. **GOLDMAN S. E., FRANKLIN R. T.** 1977. Development and feeding habits of southern pine beetle larvae. Ann. Entomol. Soc. Am. 70:54-56. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, PUPAE, ADULT, LIFE HISTORY-GENERAL, COMMENSALISM AND SYMBIOSIS The life cycle, feeding habits, and normal mortality of the larvae of *Dendroctonus frontalis* under Georgia Piedmont conditions were investigated in 1975. Larvae were observed in all four instars and their habits were noted up to pupation. Mortality was greatest in the first two instars.

389. **GOYER R. A., FINGER C. K.** 1980. Relative abundance and seasonal distribution of the major hymenopterous parasites of the southern pine beetle, *Dendroctonus frontalis* Zimmermann, on loblolly pine. Environ. Entomol. 9:97-100. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, PREDATOR, PARASITES, ECOLOGICAL DISTRIBUTION, SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION Seasonal distribution of the six most abundant southern pine beetle parasitic Hymenoptera indicated a peak abundance between April and June, with low levels present from December to March. Bark thickness reduced population density for those species ovipositing through the bark, but did not affect *Roptrocerus eccoplogastri*, which enters the host galleries.

390. **GOYER R. A., LENHARD G. J., NEBEKER T. E., JARRARD L. D.** 1980. How to identify common insect associates of the southern pine beetle. USDA Comb. For. Pest. Res. and Dev. Prog. Agric. Handb. No. 563. 33 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMPETITION, PREDATOR, PARASITES This guide includes the most representative insect associates of *Dendroctonus frontalis*. The descriptions are most useful in distinguishing a species or species group. The handbook is arranged by Order, Family, and the scientific name with the authority. Color photographs and line drawings enhance the usability of this excellent reference manual.

391. **GOYER R. A., SMITH M. T.** 1981. The feeding potential of *Corticeus glaber* and *Corticeus parallelus* (Coleoptera: Tenebrionidae), facultative predators of the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 113:807-811. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. TENEBRIONIDAE; *Corticeus glaber*, *Corticeus parallelus*). COMPETITION, PREDATOR Under laboratory conditions, *Corticeus glaber*, and *C. parallelus* were facultative predators of southern pine beetle eggs and first and second instar larvae.

392. **GREEN C. L., MCCARTY F. A., EDSON L. S., PAYNE T. L.** 1980. Apparatus for sticky trap washing and insect recovery. Southwest. Entomol. 5:19-21. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TRAPS AND CAGES, MISCELLANEOUS TECHNIQUES Recovery of insects from sticky traps is facilitated by the use of an apparatus for washing the traps.

393. **GUNTER E. R.** 1957. The southern pine beetle. La. For. Comm. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CHEMICAL, SURVEY AND DETECTION Describes *Dendroctonus frontalis* as a menace to Louisiana's pine forest. The 1957 outbreak was the first recorded outbreak in Louisiana since 1918. Describes damage and generalized life history. Recommended controls include benzene hexachloride and diesel fuel. Detection includes aerial survey, followed by checks on ownership and identification of the beetle. Follow-up inspections are needed.

394. **HAIN F. P.** 1980. Chapter 6. Sampling and predicting population trends. The southern pine beetle. *In*, R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Tech. Bull. 1631. p. 107-135. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, POPULATION DYNAMICS, STAND CONDITIONS Survey systems for southern pine beetle include aerial systems augmented by Loran-C navigation systems. Multistage sampling correlating aerial and ground surveys were performed. Sampling to estimate southern pine beetle populations include sampling within-tree populations, including attacking adults, eggs, emergence, and tree geometry models (TG-PDF). Within-spot population's could be monitored with TG-PDF. Area-wide population surveys include the incorporation of spot-growth models in Texas and Arkansas. Spot-growth models were developed in East Texas and in the Georgia Piedmont. TAMBEETLE is a southern pine beetle infestation dynamics model incorporating reproduction and mortality of beetles in an infested spot. FRONSIM estimates timber mortality from southern pine beetle over large areas. DAMBUGS combines a spot growth model with a spot incidence model.

395. **HAIN F. P., DEMARS C. J., MCCLELLAND W. T., MAWBY W. D.** 1979. Relating tree mortality to collapsing beetle populations. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb. 1, 1979, Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 54-62. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, SURVEY AND DETECTION A fast decline of a large southern pine beetle spot was monitored using aerial photography and within-tree population sampling. It is thought this decline closely simulates what could be expected in a southern pine beetle spot in which control measures had been applied.

396. **HAIN F. P., MCCLELLAND W. T.** 1979. Studies of declining and low level populations of the southern pine beetle in North Carolina. *In*, Population Dynamics For. Insects At Low Levels, Work Conf. Aug. 1979, N. C. State Univ., F. P. Hain Ed. p. 9-26. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). POPULATION DYNAMICS, HAZARD/RISK RATING Environmental factors including a rainfall deficit for eight years, dense stand stocking, high basal area with markedly reduced growth rates, and very poor soil drainage conditions typify stands in the Delmarva Peninsula of Delaware, Maryland, and Virginia infested by the southern pine beetle. In stands where these conditions exist a mixed pine-hardwood management system is recommended.

397. **HAIN F. P., MCCLELLAND W. T., POPE D. N., PULLEY P. E., FOLTZ J. L., COULSON R. N.** 1978. Standardized within-tree sampling for populations of *Dendroctonus frontalis*. Environ. Entomol. 7:157-164. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, STATISTICAL METHODS Procedures for sampling and estimating populations of southern pine beetle developed in East Texas were evaluated for their applicability for use in North Carolina. The within-tree distribution of southern pine beetle in North Carolina were not significantly different from the Texas data base, despite differences in total numbers. Tree geometry models were satisfactory for use in North Carolina. The quantitative sampling procedures developed can be used in other regions of the southern pine beetle range and under different population levels.

398. **HAINES L. W., HAINES S. G., LILES F. T. JR.** 1976. Effects of fertilization on susceptibility of loblolly pine to the southern pine beetle. School of For. Res., N. C. State Univ., Raleigh., Tech. Rep No. 58. 55 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, HOST RESISTANCE, CONTROL-

CULTURAL Since only four percent of areas surveyed had active southern pine beetle infestations, the survey did not substantiate the hypothesis. It was found that single suppressed tree southern pine beetle infestations are common in overstocked stands, while in thinned plots southern pine beetle seems to be associated with the black turpentine beetle (*D. terebrans*). So thinning which may be prescribed as a remedial treatment for 'southern pine beetle prone stands' can actually increase southern pine beetle activity.

399. **HAMMERLE W. C.** 1952. The forest insect problem in southern pine. For. Farmer 11(7):8-9,13,16. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). IMPACT Damage by the southern pine beetle is discussed along with economic implications. The need for research is stressed.

400. **HANSON J. B., BAKER B. H., BARRY P. J.** 1973. Southern pine beetle on the Delmarva Peninsula in 1971. J. Ga. Entomol. Soc. 8:157-164. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, ECOLOGICAL DISTRIBUTION, CONTROL-GENERAL, CONTROL-CULTURAL, ECONOMICS, IMPACT, REVIEW The southern pine beetle is a reoccurring problem on the Delmarva Peninsula killing 55 million board feet of timber in 1970. Stand/site conditions included dense, overstocked stands, poor soil drainage and rainfall deficit.

401. **HANSON J. B., BARRY P. J., BAKER B. H.** 1971. Southern pine beetle evaluation on the Delmarva Peninsula-1971. USDA For. Serv. Northeast. and Southeast. Areas, State and Priv. For., For. Pest Manage., Environ. Prot. and Improvement Unit. 16 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, REVIEW, HAZARD/RISK RATING *Dendroctonus frontalis* caused serious losses to loblolly and Virginia pines on the Delmarva Peninsula of Delaware, Maryland and Virginia in 1971. From aerial photographs, 254 suspected spots were detected on photographs; ground checks of 72 spots showed 2737 trees with 314 having active brood. The typical stand attacked was approximately 35 years old, densely stocked, with reduced radial increment, on poorly drained soils, and had experienced precipitation abnormalities. The survey represented 1.12 million acres.

402. **HANSON S.** 1940. The prevention of outbreaks of the pine beetles under war-time conditions. Bull. Entomol. Res. 31. p. 247-251. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW The prevention of pine beetle outbreaks under wartime conditions is discussed.

403. **HAPP G. M., HAPP C. M., BARRAS S. J.** 1971. Fine structure of the prothoracic mycangium, a chamber for the culture of symbiotic fungi, in the southern pine beetle, *Dendroctonus frontalis*. Tissue And Cell 3(2):295-308. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). OVIPOSITION, COMMENSALISM AND SYMBIOSIS, MORPHOLOGY AND PHYSIOLOGY The ultrastructure of the prothoracic mycangium of the female *Dendroctonus frontalis* is presented in detail.

404. **HAPP G. M., HAPP C. M., BARRAS S. J.** 1975. Bark beetle-fungal symbiosis. III. Ultrastructure of conidiogenesis in a *Sporothrix* ectosymbiont of the southern pine beetle. Can. J. Bot. 53:2702-2711. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Ceratocystis minor; Sporothrix*). COMMENSALISM AND SYMBIOSIS, VECTOR, TAXONOMY An isolate of *Ceratocystis minor* found in a *Sporothrix* imperfect state as an ectosymbiont of *Dendroctonus frontalis* is described and called SJB 133. In the yeast stage its structure is similar to *Sporotrichum schenckii* but differs in several ways: 1) the cell wall of SJB 133 in the yeast stage has a low affinity for electron stains; 2) the cells of SJB 133 tend to be pyriform not fusiform; and 3) SJB 133 has distinct paramural pockets not found in the yeast phase of *S. schenckii*.

405. **HAPP G. M., HAPP C. M., BARRAS S. J.** 1976. Bark beetle-fungal symbiosis: II. Fine structure of a basidiomycetous ectosymbiont of the southern pine beetle. Can. J. Bot. 54:1049-1062. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). COMMENSALISM AND SYMBIOSIS Within the mycangium of the southern pine beetle a basidiomycetous yeast (a dimorphic fungal ectosymbiont) grows. The yeast and mycelial stages are described, and the morphology and fine structure characterized.

406. **HARRAR J. G., ELLIS R. P.** 1940. The biology of a species of *Beauveria* from the southern pine bark beetle. Va. Acad. Sci. 1:211. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Beauvaria*). LARVAE, PATHOGENS *Beauvaria* sp. was isolated from larvae of southern pine beetle.

407. **HARRAR J. G., MARTLAND J. G.** 1940a. A fungous parasite of the pine bark beetle. Phytopathology 30:8. (COLEOPTERA: SCOLYTIDAE; *Dendrootonus frontalis. Beauvaria*). PATHOGENS A species of *Beauvaria* was reared from *Dendroctonus frontalis*.

408. **HARRAR J. G., MARTLAND J. G.** 1940b. The etiology of the *Beauveria* disease of *Dendroctonus frontalis*. Va. Acad. Sci. 1:211. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Beauvaria*). PATHOGENS Isolates of *Beauvaria* sp. from the southern pine beetle were used to inoculate the southern pine beetle and other insects for infection studies.

409. **HARRISON R. P.** 1956. Pine bark beetles and their control in Georgia. Ga. For. Res. Counc. Rep. No. 2. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). LIFE HISTORY-GENERAL, CONTROL-GENERAL Gives life history and chemical control using BHC for the southern pine bark beetle complex.

410. **HASTINGS F. L., COSTER J. E., EDS.** 1981. Field and laboratory evaluations of insecticides for southern pine beetle control. USDA For. Serv. Southeast. For. Exp. Stn. Gen. Tech. Rep. SE-21, Asheville, N.C. 40 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Insecticide evaluations for southern pine beetle control are summarized. Studies include screening tests, efficacy studies for prevention and remedial effects, residue studies, soil and litter studies, and phytotoxic investigations.

411. **HASTINGS F. L., JONES A. S.** 1976. Contact toxicity of 29 insecticides to southern pine beetle adults. USDA For. Serv. Res. Note SE-245. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Of 29 insecticides tested against southern pine beetle adults, 17 were more toxic than the reference (lindane). The testing considered four factors: 1) beetle living conditions, 2) easy beetle removal for mortality observations, 3) excluding effects of temperature, humidity, and possible fumigant action of the test pesticide; and 4) discouraging aggressive beetle behavior. Results indicate that several tested insecticides might effectively replace lindane and BHC. A method of successfully holding southern pine beetle for laboratory studies is also described.

412. **HASTINGS F. L., JONES A. S., FRANKLIN C. K.** 1981a. Observations on phytotoxicity. *In*, Field and laboratory evaluations of insecticides for southern pine beetle control, Hastings, F. L. and J. E. Coster, Eds. USDA For. Serv. South. For. Exp. Stn. Gen. Tech. Rep. SE-21, Asheville, N. C. p. 18-19. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, MISCELLANEOUS TECHNIQUES, BACTERIA Chlorpyrifos concentrations of 2%, 4% and 8% caused no phytotoxicity problems in southern pines. Chlorpyrifos is unlikely to be harmful to soil microbes. Fenitrothion caused no phytotoxic damage to southern pines when applied in 4% and 8% concentrations. There was no damage to soil fungi and bacteria.

413. **HASTINGS F. L., JONES A. S., FRANKLIN C. K.** 1981b. Screening tests. *In*, Field and laboratory evaluations of insecticides for southern pine beetle control, Hastings, F. L. and J. E. Coster, Eds. USDA For. Serv. South. For. Exp. Stn. Gen. Tech. Rep. SE-21, Asheville, N. C. p. 1-2. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, MISCELLANEOUS TECHNIQUES Twelve insecticides were bioassayed for contact toxicity to the southern pine beetle. Four treatments were made, at 2, 1, 0.5, and 0.25 percent concentrations for each insecticide.

414. **HASTINGS F. L., JONES A. S., FRANKLIN C. K.** 1981c. Soil and litter mesofauna studies. *In*, Field and laboratory evaluations of insecticides for southern pine beetle control, Hastings, F. L. and J. E. Coster, Eds. USDA For. Serv. South. For. Exp. Stn. Gen. Tech. Rep. SE-21, Asheville, N. C. p. 15. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, MITES In field studies, the effects of lindane and chlorpyrifos-methyl on litter and soil organisms were evaluated. Litter organisms were the most affected, especially the collembolans whose populations were significantly decreased by both insecticides. Soil organisms were not numerous and were not severely affected by the insecticides.

415. **HASTINGS F. L., JONES A. S., KISLOW C. J.** 1977. Outlook for new insecticides for bark beetle control. *In*, Lightwood Res. Coordinating Counc. Proc. Annu. Meet. Jan. 18-19, 1977, Atlantic Beach., Fla., p. 25-32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Contact toxicity data are shown for 12 insecticides which are more toxic than lindane against the southern pine beetle. Results indicate that Reldan (chlorpyrifos-methyl) at 0.5-1.0% concentrations has potential in preventing new southern pine beetle outbreaks.

416. **HASTINGS F. L., KISLOW C. J., JONES A. S., METZ L. J.** 1981. Comparison of lindane and chlorpyrifos-methyl for preventive control of the southern pine beetle. J. Ga. Entomol. Soc. 16:396-407. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Both lindane and chlorphyrifos-methyl provided preventative control for the southern pine beetle.

417. **HAY E.** 1976. America's 8 biggest forest killers. Am. For. 82(4):21-23. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Briefly describes impact by forest insects.

418. **HEDDEN R. L.** 1978a. Host tree spatial pattern in a southern pine beetle infestation. Southwest. Nat. 23(1)71-75. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, STATISTICAL METHODS The host tree spatial pattern of a southern pine beetle infestation was investigated. Data obtained using distance to other host trees and variance-to-mean ratios showed that the number of trees in a sample plot was inversely related to average DBH. The spatial pattern of trees in the area was regular. When the beetles reached a plot where trees were spaced at greater than 6.1 meters, the spot did not expand.

419. **HEDDEN R. L.** 1978b. The need for intensive forest management to reduce southern pine beetle activity in East Texas. South. J. Appl. For. 2:19-22. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, ECONOMICS, IMPACT Forest land acreages in East Texas have declined while demands on it continue to increase. Southern pine beetle populations have increased because of the increase in high density pine stands. This trend is expected to continue. To minimize southern pine beetle losses, intensive forest management, including care in site selection and preparation, proper use of intermediate treatments, and early harvest cuts should be practiced.

420. **HEDDEN R. L.** 1979. Methods used for evaluating southern pine beetle control tactics. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 11-13. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL, CONTROL-CULTURAL, MODELING A review of control tactics, methods used to evaluate these tactics, problems associated with these evaluations, and suggestions for developing new methods of treatment evaluation of southern pine beetle control strategies is presented.

421. **HEDDEN R. L., BARRAS S. J., COSTER J. E., EDS.** 1981. Hazard-rating systems in forest insect pest management. Symp. Proc. Athens, Ga. (July-August 1980). USDA For. Serv. Gen. Tech. Rep. WO-27. 169 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS A symposium on hazard-rating systems in forest insect pest management explored operational systems in the United States.

422. **HEDDEN R. L., BILLINGS R. F.** 1977. Seasonal variations in fat content and size of the southern pine beetle in East Texas. Ann. Entomol. Soc. Am. 70:876-880. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, FLIGHT, MORPHOLOGY AND PHYSIOLOGY Fat content of southern pine beetles emerging during the spring and fall was greater than that of beetles during the summer and winter. Beetles were found to be smallest during July, August, and September. Females were larger and had higher fat contents than males, regardless of season. Bark beetle dispersal and seasonal behavior are discussed.

423. **HEDDEN R. L., BILLINGS R. F.** 1979. Southern pine beetle: Factors influencing the growth and decline of summer infestations in East Texas. For. Sci. 25:547-556. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS, STAND CONDITIONS Site and stand factor effects on infestation expansion in southern pine beetle infestations in East Texas indicated that the trees killed/day (TK) was positively correlated to the number of active trees in the infestation and the stand basal area. Mean rates of infestation growth were also correlated with area wide southern pine beetle population levels. A hierarchy of control priorities is supplied based on the findings.

424. **HEDDEN R. L., REED D. D.** 1980. Southern pine beetle: Factors influencing the growth and decline of summer infestations. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 145-151. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING, STAND CONDITIONS A model was developed to simulate the spread of southern pine beetle using stand variables. This model consists of two principal functions: 1) a function which predicts rate of spread in trees killed per day and 2) a prediction of the probability of a spot becoming inactive. The model can simulate spot growth.

425. **HEIKKENEN H. J.** 1977. Southern pine beetle: A hypothesis regarding its primary attractant. J. For. 75:412-413. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, HOST SELECTION A positive flight response of southern pine beetle to dead loblolly pine trees was observed during a period when the population was endemic. Volatiles emitted by the pines are thought responsible for the initial attack. It is hypothesized that the beetle's true role is a scavenger and its principal role is to carry wood-destroying fungi from tree to tree.

426. **HELLER R. C., ALDRICH R. C., BAILEY W. F.** 1959. An evaluation of aerial photography for detecting southern pine beetle damage. Photogram. Eng. 25:595-606. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES The usefulness of special aerial photography to locate and appraise insect-killed timber in North Carolina was evaluated. Several films were screened and selection was narrowed to color and panchromatic with a red filter; color film interpretations were more accurate. Color film was also more accurate than sketch mapping but was more expensive. Ground cruising proved too costly and time consuming. It was concluded that color

photography was the most useful for wide scale southern pine beetle control operations.

427. **HELLER R. C., COYNE J. F., BEAN J. L.** 1955. Airplanes increase effectiveness of southern pine beetle surveys. J. For. 53:483-487. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION A rapid and relatively inexpensive survey method was developed for conducting control operations of large southern pine beetle outbreaks. A high wing mono-plane able to hold a pilot and two observers and capable of flying at low altitudes at 90 mph or less is necessary. Using either aerial photographs or sketch maps, southern pine beetle spots can be permanently located. Observers should be familiar with aerial photographs or sketch mapping techniques. Ground checks may be used for calculation of insect aggressiveness and actual infestation information.

428. **HEMINGWAY R. W., MCGRAW G. W., BARRAS S. J.** 1977. Polyphenols in *Ceratocystis minor* infected *Pinus taeda*: Fungal metabolites, phloem and xylem phenols. J. Agric. and Food Chem. 25:717-722. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Ceratocystis minor*). VECTOR, PATHOGENS *Ceratocystis minor* is important in the death of pines attacked by the southern pine beetle. Polyphenol changes in artificially infected pine bolts were examined for accumulations of fungal metabolites and changes in concentrations of fungitoxic and fungistatic phloem and xylem constituents. Results were compared to *C. minor* grown in liquid culture. Isocumarins I and II were found in both liquid cultures and infected trees, but *alpha*-tetralone III, was found only in the liquid culture. *C. minor* was effective in degrading flavonoids and stilbenes, suggesting these play no part in host resistance to *C. minor*. Analysis for these changes in southern pine beetle infested trees is suggested for a future study.

429. **HENDRICH J. P.** 1977. Distribucion ecologica y geografica de las especies primarias de escarabajos descortezadores de pino del genero *Dendroctonus* (Coleoptera: Scolytidae) en Mexico. Thesis, Instituto Technologico y de Estudios Superiores de Monterey. 134 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TAXONOMY Describes the distribution and ecology of the genus *Dendroctonus*.

430. **HERTEL G. D.** 1981. Implementation experiences: An overview. *In*, Hazard-rating Systems in Forest Insect Pest Management: Symp. Proc., Athens, Georgia, 31 July - 1 August 1980, R. L. Hedden, S. J. Barras and J. E. Coster, Eds. USDA For. Serv. Gen. Tech. Rep. WO-27. p. 13-21. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS, INTEGRATED PEST MANAGEMENT The tenets of technology transfer are summarized. Hazard-rating systems for the southern pine beetle are reviewed for the southeastern United States.

431. **HERTEL G. D., COMPILER.** 1980. Chapter 12. Recommendations for future work. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Tech. Bull. 1631. p. 205-213. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TECHNOLOGY TRANSFER, INTEGRATED PEST MANAGEMENT Future work includes technology transfer, development and refinement of aerial survey systems, sampling, economics, silvicultural and stand rating systems, use of southern pine beetle-killed timber and improved insecticide applications and compounds. Technology transfer and implementation is stressed.

432. **HERTERT H. D.** 1976. Severity of *Fomitopsis annosa* infection in relation to southern pine beetle attacks in loblolly pine. Proc. Am. Phytopathol. Soc. (Abst.) 3:326-327. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Heterobasidion annosum*). PARASITES, PATHOGENS In a study to evaluate *Heterobasidion annosum* as a predisposing agent to *Dendroctonus frontalis*, the severity of the southern pine beetle infested tree was nearly twice as infected with *H. annosum* as the tree with no southern pine beetle infestation.

433. **HETRICK L. A.** 1940. Some factors in natural control of the southern pine beetle, *Dendroctonus frontalis* Zimm. J. Econ. Entomol. 33:554-556. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, CONTROL-BIOLOGICAL, ECONOMICS, IMPACT, MITES, NEMATODES There was a high mortality of southern pine beetle in eastern Virginia in 1939. Nematodes were present in living and dead bark beetles of all stages. Mites were found on the bodies of adult beetles. An abundant bird and insect predator population, mild weather, and normal precipitation levels occurred during the winter. These biological factors are offered as one possible explanation of the sudden subsidence of the southern pine beetle outbreak.

434. **HETRICK L. A.** 1941. Minutes of the 520th regular meeting of the Entomological Society of Washington. June 5, 1941. 2. Forest insect investigations of the Virginia Agricultural Experiment Station. Proc. Entomol. Soc. Wash. 43:168. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Anguillonema*, *Beauvaria*). CONTROL-BIOLOGICAL, SURVEY AND DETECTION Reviews establishment of biological agents attacking the southern pine beetle.

435. **HETRICK L. A.** 1949a. Susceptibility of pine trees to bark beetle attack. Arbor. News 14(12):149-151. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). LIFE HISTORY-GENERAL, POPULATION DYNAMICS, ATTRACTANTS, HOST SELECTION, CONTROL-GENERAL, LIGHTNING Predisposing factors for several bark beetle genera are discussed; these factors include rainfall deficiencies, lightning, root damage, long-standing slab piles, and diseases. The importance of maintaining healthy roots is mentioned.

436. **HETRICK L. A.** 1949b. Some overlooked relationships of southern pine beetle. Assoc. South. Agric. Workers Proc. 46:93-94. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Pines with damage to their root systems are more susceptible to the southern pine beetle than those with damage to either the bole or limbs. Brood development is arrested when infested logs are dumped into water.

437. **HETRICK L. A.** 1949c. Some overlooked relationships of southern pine beetle. J. Econ. Entomol. 42:466-469. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, ECOLOGICAL DISTRIBUTION, SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, DISTRIBUTION, CONTROL-GENERAL, WEATHER RELATIONSHIPS, LIGHTNING This paper records misunderstood relationships between the southern pine beetle and the trees it infests. Included are discussions on precipitation extremes, root stress, lightning strikes, blue stain, and predation and parasitism.

438. **HETRICK L. A.** 1960. Factors that contribute to pine bark beetle attack. For. Farmer 19(10):12,16. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). HOST SELECTION, STAND CONDITIONS, LIGHTNING Reviews the role of the five southern pine beetle species in southern forestry. Concludes lowered water tables, excessive standing water, lightning, and root injury lead to the decline and subsequent attack by bark beetles.

439. **HICKS R. R. JR.** 1980. Chapter 4. Climatic, site, and stand factors. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Tech. Bull. 1631. p. 55-68. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, HAZARD/RISK RATING, LIGHTNING Climatic factors include rainfall, temperature and lightning. Site factors are related to landform, water regime, soil texture, soil chemical properties and site index. Stand factors are stand density, radial growth, species composition, and stand parameters. Southwide, host susceptibility is related to low vigor and/or stress.

440. **HICKS R. R. JR., COSTER J. E., WATTERSTON K. G.** 1978. Reliability of field crew judgements concerning site factors associated with southern pine beetle infestations. Southwest. Entomol. 3:52-58. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, CONTROL-CULTURAL, MODELING,

HAZARD/RISK RATING Soil moisture regime, texture and landform are potentially useful for risk rating in eastern Texas. Field foresters who have had little specialized training can classify these characteristics, although soil texture may require some special training.

441. **HICKS R. R. JR., COSTER J. E., WATTERSTON K. G.** 1979. Reducing southern pine beetle risks through proper management planning. For. Farmer 38(7):6-7,18. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL, ECONOMICS, IMPACT, REVIEW, HAZARD/RISK RATING Proper management of pine forests can effectively reduce southern pine beetle damage. Conditions associated with high susceptibility to southern pine beetle are pines growing on chronically wet or water logged soils, and over crowded pine stands. In wetlands, slash pine or a hardwood species could be planted. Thinning is best applied in early fall or winter, or when beetle activity is low.

442. **HICKS R. R. JR., HOWARD J. E., COSTER J. E., WATTERSTON K. G.** 1978. The role of tree vigor in susceptibility of loblolly pine to southern pine beetle. *In*, Proc., Fifth North Am. For. Biol. Workshop, Univ. Fla., Gainesville. p. 177-186. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Heterobasidion annosum*). HOST SELECTION, HOST RESISTANCE, STATISTICAL METHODS, MODELING, PATHOGENS Samples were taken from 218 southern pine beetle infested and 209 non-infested loblolly pine stands in East Texas. Five year radial growth was used as a measure of tree vigor. By using discriminant analysis, 84% of infested samples on excessively wet sites were correctly classified. Samples on moist, dry, or droughty sites were not as readily classified by baseline data. The most important variable associated with radial growth was pine basal area per acre.

443. **HICKS R. R. JR., HOWARD J. E., WATTERSTON K. G., COSTER J. E.** 1980a. Rating East Texas stands for southern pine beetle susceptibility. South. J. Appl. For. 5:7-10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, STAND CONDITIONS, HAZARD/RISK RATING A stand rating model was developed which predicts the probability of southern pine beetle attack over a 3-year period in East Texas. The data required for the model is pine basal area/ha, average tree height, and landform category. Data were collected from over 900 infested and non-infested pine stands in East Texas.

444. **HICKS R. R. JR., HOWARD J. E., WATTERSTON K. G., COSTER J. E.** 1980b. Rating forest stand susceptibility to southern pine beetle in East Texas. For. Ecol. and Manage . 2:269-283. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, STATISTICAL METHODS, MODELING, HAZARD/RISK RATING A stand rating system was developed from 900 southern pine beetle-infested and non-infested pine stands in East Texas. Given certain geographical constraints and epidemic population levels, a 3-year probability of southern pine beetle attack prediction can be made. Three variables needed include: 1) pine basal area per ha, 2) average tree height, and 3) a categorical evaluation of land form. Stand rating models should be used in stand management. This allows for the surveillance and control tactics to be concentrated in high-hazard stands.

445. **HICKS R. R. JR., MASON G. N.** 1982. Southern pine beetle hazard rating works in east Texas. Southwest. Entomol. 7:174-180. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS Southern pine beetle damage occurred at five times the rate in high hazard stands compared to low hazard stands in East Texas.

446. **HICKS R. R. JR., WATTERSTON K. G., COSTER J. E., HOWARD J. E.** 1981. Gulf Costal Plain, eastern Texas. *In*, Site, stand and host characteristics of southern pine beetle infestations, J. E. Coster and J. L. Searcy, Eds. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. 1612. p. 8-15. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS, LIGHTNING Site and stand characteristics of attacked and baseline plots in natural, undisturbed stands, landform, basal area, and stand disturbances were analyzed for hazard rating for the southern pine beetle. One-third of the southern pine beetle infestations were induced by disturbances, such as lightning or logging unrelated to site, stand, or host characteristics. The remaining spots were associated with low-lying sites with over-stocked stands.

447. **HINDS W. E.** 1912. The southern pine beetle and its control. Ala. Agric. Exp. Stn. Circ. No. 15 Post. Pub. Co., Opelika, Ala. p. 46-58. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL, REVIEW, LIGHTNING Describes life history and initial signs of southern pine beetle attack, including pitch tubes, and s-shaped galleries. Conditions favoring injury include lightning-struck trees and trees injured by storms. Southern pine beetle-infested trees may be located by fresh boring dust, faded tops, attack of sawyer beetles and bark beetle brood. Methods of control include removing and burning infested bark, or placing infested trees in water (note: cost of control should not exceed an average of one to five cents per acre for pine-covered land or two cents per cord for living timber).

448. **HINES G. S.** 1979. A simulation model for investigating the population dynamics of *Dendroctonus frontalis* Zimm. Ph.D. Diss., Univ. Arkansas, Fayetteville, Arkansas. 115 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, PUPAE, ADULT, STATISTICAL METHODS, MODELING A computer model simulating the life cycle of the southern pine beetle was developed. The model produces predictions at weekly intervals of the number of dead and infested trees as well as estimates of pulpwood and sawtimber losses. A procedure for validating the model is presented.

449. **HINES G. S., STEPHEN F. M., TAHA H. A.** 1980. Uses and structure of a simulation model for investigating the dynamics of a southern pine beetle. *In*, Proc. 1980 Summer Computer Simulation Conf., Seattle, WA. Aug., 1980. p. 696-699. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, POPULATION DYNAMICS A computer simulation model to simulate the life cycle of the southern pine beetle was developed. The model produces weekly predictions of the number of dead and dying trees and estimates of economic loss for pulpwood and sawtimber.

450. **HINES G. S., TAHA H. A., STEPHEN F. M.** 1980. Model for predicting southern pine beetle population growth and tree mortality. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 4-12. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING A deterministic model for predicting southern pine beetle population growth and tree mortality is presented. Population growth is primarily a function of temperature, and other variables affecting mortality and production rates, thereby regulating growth. With this model one can predict at weekly intervals the numbers of dead and infested trees, as well as the expected monetary loss reflecting local stumpage prices.

451. **HITCHINGS R. G., LEVI M. P.** 1981. Southern pine beetle-killed trees can be salvaged by kraft pulping. Pulp and Pap. 55:156-159. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION The effects of chips from southern pine beetle-killed trees on kraft pulp quality were determined and are discussed here. More alkali is needed by southern pine beetle-killed wood to attain the same screened yield and koppa number as healthy wood.

452. **HODGES J. D., BARRAS S. J.** 1974. Fatty-acid composition of *Dendroctonus frontalis* at various developmental stages. Ann. Entomol. Soc. Am. 67:51-54. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, PUPAE, MORPHOLOGY AND PHYSIOLOGY The fatty acids of the neutral lipid (NL) and phospholipid (PL) fractions of the southern pine beetle were examined at the egg, inner-bark larval, outer-bark larval, pupal, emerging adult and attacking adult stages. The oleic fraction made up of 29-51% of fatty acids in all life stages; palmitic acid was second most common at 16-24% except in the eggs and attacking females, which had a higher linoleic content at 28 and 24% respectively. In the eggs,

short chain compounds accounted for more than one-half the fatty acids.

453. **HODGES J. D., BARRAS S. J., MAULDIN J. K. 1968a.** Amino acids in inner bark of loblolly pine, as affected by the southern pine beetle and associated microorganisms. Can. J. Bot. 46:1467-1472. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, MISCELLANEOUS TECHNIQUES, MORPHOLOGY AND PHYSIOLOGY Infecting loblolly pine with two southern pine beetle associated microorganisms resulted in no qualitative changes in free amino acids and minor changes in protein-bound amino acids. The concentration of free amino acids and soluble nitrogen decreased and most protein-bound amino acids, insoluble N, and total N increased. The fungi may influence beetle development through changes in chemical compounds other than amino acids.

454. **HODGES J. D., BARRAS S. J., MAULDIN J. K. 1968b.** Free and protein-bound amino acids in inner bark of loblolly pine. For. Sci. 14:330-333. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, MISCELLANEOUS TECHNIQUES This paper is part of a larger study looking at amino acids resulting from the activity of microorganisms alone or in combination with the southern pine beetle. Here the results of a preliminary study using an amino acid analyzer in the inner bark of a loblolly pine (freshly felled) are reported. Results showed 34 free amino acids (20 showed up in the protein faction). Free acid concentration was higher at the upper levels of the tree while the reverse was true for protein-bound amino acids. Free acid concentrations decreased over time, while protein-bound acids increased overtime.

455. **HODGES J. D., ELAM W. W., WATSON W. F. 1977.** Physical properties of the oleoresin system of the four major southern pines. Can. J. For. Res. 7:520-525. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE The four major southern pines (*Pinus elliottii*, *P. palustris*, *P. taeda* and *P. echinata*) were studied in central Louisiana to determine the oleoresin viscosity, flow, and rate of crystallization. Physical properties of the oleoresin and tree morphological characteristics (dbh, growth rate, height, etc.) were not strongly related in any of the four species. Slash pine had a highly viscous oleoresin which crystallized slowly and had a very slow rate of flow. Longleaf oleoresin was moderately viscous and had a high yield with a high rate of flow. Loblolly and shortleaf pine had oleoresin with low viscosity, a moderate to low yield, a short flow duration, and a fast rate of crystallization. This information is used to assess tree susceptiblity to attack by the southern pine beetle.

456. **HODGES J. D., ELAM W. W., WATSON W. F., NEBEKER T. E. 1979.** Oleoresin characteristics and susceptibility of four southern pines to southern pine beetle (Coleoptera: Scolytidae) attacks. Can. Entomol. 111:889-896. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, HOST RESISTANCE Oleoresin from more than 50 trees of each of the four major southern pine species was tested for composition, amount of monoterpenes, resin acids viscosity, flow (rate-duration and amount), and rate of crystallization. Using discriminant function analysis, loblolly and shortleaf pine trees were classified as to probable resistance. Total flow, flow rate, viscosity, and time to crystalize proved the most discriminating variables. After infesting supposedly resistant and susceptible trees, the chemical and physical properties of those surveyed were measured. It is concluded that resistance is strongly related to physical properties of the oleoresin and can be predicted.

457. **HODGES J. D., LORIO P. L. JR. 1968.** Measurement of oleoresin exudation pressure in loblolly pine. For. Sci. 14:75-76. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE, MISCELLANEOUS TECHNIQUES An inexpensive disposable device for measuring oleoresin exudation pressure in loblolly pine is described. The device consists of glass capillary tubing inserted into a hole bored into the tree bole. Oleoresin pressure is a factor in repelling attacks of bark beetles.

458. **HODGES J. D., LORIO P. L. JR. 1969.** Carbohydrate and nitrogen fractions of the inner bark of loblolly pines under moisture stress. Can. J. Bot. 47:1651-1657. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION Using 40 year old loblolly pines (one-half subjected to drought, one-half control), reducing sugars, nonreducing sugars, total carbohydrates, and starches were measured. Those trees subjected to drought showed a marked increase in all but starch, which showed a marked decrease. It is thought that the increase in sugars is primarily the result of decreased growth rate and not hydrolysis of starch. Trees stressed by flooding showed the same symptoms: stress attributed to root failure. The increase in sugars may be a major factor influencing population increases in the southern pine beetle, as beetle populations increase dramatically during extremes of moisture stress.

459. **HODGES J. D., LORIO P. L. JR. 1973.** Comparison of oleoresin composition in declining and healthy loblolly pines. USDA For. Serv. South. For. Exp. Stn. Res. Note SO-158. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE Through gas chromatography of the oleoresin of both declining and healthy trees, no difference in monoterpene or resin acid composition could be detected. It is hypothesized that the reduction in resin production and a decreased oleoresin reservoir (and not its composition) accounts for the tree's increased susceptibility to beetle attack. The decrease in physical resistance seems to be the most probable predisposer. A list of monoterpenes and resin acids is included.

460. **HODGES J. D., LORIO P. L. JR. 1975.** Moisture stress and composition of xylem oleoresin in loblolly pine. For. Sci. 21:283-290. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE, PATHOGENS Two tests in the lower Gulf Coastal Plain and one in the Upper Coastal Plain were carried out over a 3-year period to determine the effect of moisture stress on xylem oleoresin composition over a 3-year period. Stress decreased the resin acid to monoterpene hydrocarbon ratio; most of the change in resin acids was due to a decrease in levopimaric plus palustric acid, while most of the change in monoterpene hydrocarbons was due to an increase in *alpha*- and *beta*-pinene. The greatest changes noted were the large loss of tree roots to rootlet pathogens. It is believed the changes in oleoresin play a large role in the attraction of bark beetles, especially the southern pine beetle.

461. **HODGES J. D., PICKARD L. S. 1971.** Lightning in the ecology of the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 103:44-51. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, HOST SELECTION, HOST RESISTANCE, MISCELLANEOUS TECHNIQUES, WEATHER RELATIONSHIPS, LIGHTNING Lightning strikes are important in sustaining southern pine beetle populations. The lightning struck tree offers a favorable attack and brood environment for the beetle. Lightning strikes reduce oleoresin pressure, oleoresin flow, and relative water content of inner-bark tissue. Sucrose levels are decreased and there is an increase in the reducing-sugar content of the inner bark.

462. **HODGES J. D., THATCHER R. C. 1976.** Southern pine beetle survival in trees felled by the cut and top-cut and leave method. USDA South. For. Exp. Stn. Res. Note SO-219. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CULTURAL The cut-and-top method used to control the southern pine beetle resulted in lower beetle survival (17%) in both the hot and cold seasons. Survival was evidently related to high inner-bark moisture levels, 61% for cut-and-top trees and 51% for cut-and-leave. Survival was greatest in September, and relatively low in June, December and January. Most beetle mortality (74%) occurred before larvae reached the mid-to-late larval stage for trees felled in June and July. In December and January almost all mortality occurred between late-larval stage and emergence. Cutting and topping into an opening may decrease brood survival, especially if the entire log is exposed to direct sunlight.

463. **HOFFMANN C. H., ANDERSON R. F. 1945.** Effect of southern pine beetle on timber losses and natural restocking. J. For. 43:436-439. (COLEOPTERA: SCOLYTIDAE;

Dendroctonus frontalis). HOST SELECTION, HOST RESISTANCE, ECONOMICS, IMPACT This paper presents information obtained through 24 years of record keeping on the Bent Creek watershed in the Appalachian Forest Experiment Station. In formation on: 1) timber losses, 2) vulnerability of attack on pure versus mixed stand, and 3) natural restocking of openings was considered. Small timber losses were observed over the 24 year period. Mixed stands are less susceptible than pure pine. Pine seedlings did not restock openings formed after southern pine beetle attacks.

464. **HOFFMANN C. H., ST. GEORGE R. A.** 1949. Timber stand improvement in the Southern Applachian Region. USDA Misc. Publ. No. 693. p. 70-73. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CHEMICAL Summarizes the life history and control for the southern pine beetle, including chemical control with orthodichlorobenzene.

465. **HOLST E. C.** 1936. *Zygosaccharomyces pini*, a new species of yeast associated with bark beetles in pines. J. Agric. Res. 53:513-518. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus brevicomis, Ips avulsus, Ips grandicollis, Ips calligraphus*). MISCELLANEOUS TECHNIQUES, COMMENSALISM AND SYMBIOSIS A yeast (*Zygosaccharomyces pini*) is described as a new species found in association with bark beetles; it has been identified in association with *Dendroctonus brevicomis, D. frontalis, D. valens, Ips oregoni, I. emarginatus, I. avulsus, I. grandicollis*, and *I. calligraphus*. The genus was determined since ascospore formation is preceded by a sexual process. The formation of hat-shaped ascospores, along with the fact that only glucose, fructose, and mannose are fermented make it necessary to consider this yeast a new species.

466. **HOLST E. C.** 1937. Aseptic rearing of bark beetles. J . Econ. Entomol. 30:676-677. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips calligraphus, Ips grandicollis*). EGG, LARVAE, PUPAE, REARING Bark beetle eggs were removed and placed on malt agar slants, surface sterilized, and transferred to phloem for rearing.

467. **HOPKINS A. D.** 1892a. Notes on a destructive forest tree scolytid. Science 20:64-65. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, SURVEY AND DETECTION Hopkins states that *Dendroctonus frontalis* attacks green healthy pines.

468. **HOPKINS A. D.** 1892b. The pine beetle of the Virginias. Hardwood 2:7-8. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-BIOLOGICAL Hopkins summarizes his experience with *Dendroctonus frontalis* in the Virginias. Included are notes on the importations of clerids for biological control, and the rapid spread of the beetle in pine stands.

469. **HOPKINS A. D.** 1893a. Catalog of West Virginia Scolytidae and their enemices with list of trees and shrubs attacked. W. Va. Agric. Exp. Stn. Bull. 31. p. 121-168. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*. CLERIDAE; *Thanasimus dubius*. HYMENOPTERA: BRACONIDAE; *Bracon pissodis*. CHALICIDAE; *Lonchites* sp., *Heydenia unica*). PREDATOR, PARASITES Hopkins lists the southern pine beetle and its parasites and predators.

470. **HOPKINS A. D.** 1893b. Catalogue of West Virginia forest and shade tree insects. Bull. No. 32 West Va. Agric. Exp. Stn. 3(8):170-251. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES Refer to A. D. Hopkins, 1893 Bull. No. 32, Agric. Exp. Stn. for *Dendroctonus frontalis* and associated predators and parasites.

471. **HOPKINS A. D.** 1893c. Catalogue of West Virginia Scolytidae and their enemies. With list of trees and shrubs attacked. Bull. No. 31 West Va. Agric. Exp. Stn. 3(7):120-168. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius, Thanasimus formicarius*. TENEBRIONIDAE; *Hypophloeus parallelus*. HYMENOPTERA: BRACONIDAE; *Bracon pirsodis*. CHALEIDIDAE; *Lochites* spp., *Heydenia* sp.). PREDATOR, PATHOGENS, PARASITES Hopkins catalogs the parasites and predators reared from the southern pine beetle from 1890-1893.

472. **HOPKINS A. D.** 1893d. Damage to forests by the destructive pine bark-beetle. USDA Div. Entomol., Insect Life 5(3):187-189. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, CONTROL-BIOLOGICAL, REVIEW, TAXONOMY A description of damage, range, and proposed controls against *Dendroctonus frontalis* in the Virginias is presented in 1893.

473. **HOPKINS A. D.** 1893e. Destructive scolytids and their imported enemy. Insect Life 6(2):123-129. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*. CLERIDAE; *Cleris formicarius*). PREDATOR, CONTROL-BIOLOGICAL Hopkins discusses the probable role of an imported clerid, *Cleris formicarius*.

474. **HOPKINS A. D.** 1893f. Report of entomologist. W. Va. Stn. Rep. p. 29-48. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*. CLERIDAE; *Thanasimus formicarius*). CONTROL-BIOLOGICAL A project was initiated to establish imported European clerid beetles in southern pine beetle infestations.

475. **HOPKINS A. D.** 1894. A serious trouble over. Hardwood VI, p. 270-271. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Hopkins reports on the southern pine beetle epidemic in the Virginias.

476. **HOPKINS A. D.** 1896. Some notes on insect enemies of trees. Can. Entomol. 28:243-250. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Discusses rapid decline of *Dendroctonus frontalis* in West Virginia in 1892.

477. **HOPKINS A. D.** 1898a. Insects detrimental and destructive to timber products. Proc. Soc. Prom. Agric. Sci. 11:103-108. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus simplex, Scolytus quadrispinosus*). LIFE HISTORY-GENERAL, ECONOMICS The habits and economic importance of the southern pine beetle and other bark beetles are discussed.

478. **HOPKINS A. D.** 1898b. Notes on Scolytidae, with descriptions of new species. Proc. Entomol. Soc. Wash. 4:81-82. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Pityophthorus frontalis, Pityophthorus fagi, Thysanoes querciperda, Thysanoes obscurus*). DISTRIBUTION, CONTROL-BIOLOGICAL Hopkins reports on southern pine beetle in 1897.

479. **HOPKINS A. D.** 1899. Report on investigations to determine the cause of unhealthy conditions of the spruce and pine from 1880-1893. W. Va. Agric. Exp. Stn. Bull. 56. i-iv, 197-461. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp. CLERIDAE; *Thanasimus dubius, Thanasimus formicarius*. HYMENOPTERA: *Heydenia unica, Cecidostiba dendroctoni, Roptrocerus eccoptogastri*). CONTROL-BIOLOGICAL, PARASITES An account of the investigation of the southern pine beetle as a destructive agent on spruce and pine in West Virginia is presented. Three thousand European clerid beetles were imported and released into a southern pine beetle infestation to investigate their effectiveness as a biological control. The southern pine beetle spot had gone inactive shortly before the inoculation so tests were inconclusive.

480. **HOPKINS A. D.** 1903. Forest-insect explorations in the summer of 1902. Can. Entomol. 35:59-61. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus ponderosae, Dendroctonus obesus, Dendroctonus valens, Dendroctonus approximatus, Phloesinus punctatus*). SURVEY AND DETECTION Hopkins reviews his travels over 27 States during 1902. The *Dendroctonus frontalis* outbreak in the Southern Appalachian region (Virginia and West Virginia) is discussed.

481. **HOPKINS A. D.** 1903. Some of the principal insect enemies of coniferous forests in the United States. Yearb. USDA 1902. p. 265-282. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus*

frontalis, *Dendroctonus* spp.). EGG, LARVAE, PUPAE, ADULT, LIFE HISTORY-GENERAL, CONTROL-CULTURAL, TAXONOMY, LIGHTNING Hopkins described the life stages and galleries of *Dendroctonus frontalis*. Controls described included felling and burning bark from infested trees, or felling and barking. Pines struck by lightning or injured by logging should be removed. Hopkins suggests the use of trap trees for southern pine beetle control.

482. **HOPKINS A. D.** 1904. Catalogue of insect enemies of forests and forest products, at the Louisiana Purchase Exposition, St. Louis. USDA Div. Entomol. Bull. 44. p. 41,44. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TAXONOMY Southern pine beetle is listed as an insect enemy in pines.

483. **HOPKINS A. D.** 1906. The principal injurious insects of 1905. USDA Yearb. 1905. p. 631-632. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Dendroctonus ponderosae*, *Scolytus quadrispinosus*). SURVEY AND DETECTION *Dendroctonus frontalis* was the principal insect enemy of pines in the southeastern United States.

484. **HOPKINS A. D.** 1907. The principal injurious insects of 1906. USDA Yearb. 1906. p. 508-517. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The southern pine beetle was increasing since the 1891-1892 outbreak.

485. **HOPKINS A. D.** 1908. Notable depredations by forest insects. Yearb. USDA, 1907 p. 163. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW A review of destructive insect epidemics and outbreaks which occurred late in the nineteenth century and early in the twentieth century.

486. **HOPKINS A. D.** 1909. Contributions toward a monograph of the scolytid beetles. I. The genus *Dendroctonus*. USDA Bur. Entomol. Tech. Series No. 17, Part I. 170 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Dendroctonus barbari*, *Dendroctonus arizonicus*, *Dendroctonus mexicanus*, *Dendroctonus parallelocollis*, *Dendroctonus approximatus*, *Dendroctonus monticolae*, *Dendroctonus ponderosae*, *Dendroctonus jeffreyi*, *Dendroctonus simplex*, *Dendroctonus pseudotsugae*, *Dendroctonus piceaperda*, *Dendroctonus engelmanni*, *Dendroctonus borealis*, *Dendroctonus obesus*, *Dendroctonus rufipennis*, *Dendroctonus murrayanae*, *Dendroctonus punctatus*, *Dendroctonus micans*, *Dendroctonus terebrans*, *Dendroctonus valens*, *Dendroctonus adjunctus*). EGG, LARVAE, PUPAE, ADULT, LIFE HISTORY-GENERAL, DISTRIBUTION, REVIEW, TAXONOMY, MORPHOLOGY AND PHYSIOLOGY A 1909 compendium of the available information concerning the taxonomy, morphology and physiology, and distribution of the genus *Dendroctonus*.

487. **HOPKINS A. D.** 1909. Practical information on the Scolytid beetles of North American Forests. I. Bark beetles of the genus *Dendroctonus*. USDA Bur. Entomol. Bull. No. 83, Part I. 169 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus barbari*, *Dendroctonus convexifrons*, *Dendroctonus arizonicus*, *Dendroctonus mexicanus*, *Dendroctonus parallelocollis*, *Dendroctonus approximatus*, *Dendroctonus monticolae*, *Dendroctonus ponderosae*, *Dendroctonus jeffreyi*, *Dendroctonus simplex*, *Dendroctonus pseudotsugae*, *Dendroctonus piceaperda*, *Dendroctonus engelmanni*, *Dendroctonus borealis*, *Dendroctonus obesus*, *Dendroctonus rufipennis*, *Dendroctonus murrayanae*, *Dendroctonus punctatus*, *Dendroctonus micans*, *Dendroctonus terebrans*, *Dendroctonus valens*). EGG, LARVAE, PUPAE, ADULT, LIFE HISTORY-GENERAL, PREDATOR, ECOLOGICAL DISTRIBUTION, SEASONAL OCCURRENCE, FLIGHT, REVIEW, TAXONOMY, STAND CONDITIONS, CONTROL-CULTURAL, LIGHTNING The seasonal history of *Dendroctonus frontalis* is outlined; four generations of *D. frontalis* are covered. Discusses the pine infestations in West Virginia in 1891-1892. External evidence of attacks is described. Favorable conditions for *D. frontalis* spread are mature timber in dense stands and lightning-struck trees. Continual removal of mature trees inhibits *D. frontalis* population buildups. Methods of control include removing and burning bark, removing larger trees, piling and burning, and water soaking. A clerid beetle, *Clerus formicarius*, is illustrated. References to Hopkins' articles are included. The 'Arizona pine beetle' is described.

488. **HOPKINS A. D.** 1910. Insects which kill forest trees: Character and extent of their depredations and methods of control. USDA Bur. Entomol. Bull. 58, Part V. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CULTURAL, SURVEY AND DETECTION Hopkins summarizes the life history and controls for the southern pine beetle. Controls included felling and burning, placing infested trees in water, barking trees, or utilizing the material.

489. **HOPKINS A. D.** 1911. The dying of pine in the southern states: Cause, extent, and remedy. USDA Farmers' Bull. 476. 15 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CULTURAL Hopkins summarizes the extent of damage by the southern pine beetle in the southern United States prior to 1911. The life history of the southern pine beetle is detailed. Controls outlined included burning infested trees, removing the bark, and placing infested trees in water. Control operations were best done from November through February.

490. **HOPKINS A. D.** 1919. The bioclimatic law as applied to entomological research and farm practise. Sci. Mon. 8:496-513. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Dendroctonus ponderosae* = *monticolae*). WEATHER RELATIONSHIPS Hopkins relates his bioclimatic law to control of bark beetles.

491. **HOPKINS A. D.** 1921. The southern pine beetle: A menace to the pine timber of the Southern States. USDA Farmers' Bull. 1188. 15 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL An overview of southern pine beetle's activity, damage, range, and proposed control tactics is presented in 1921.

492. **HOPKINS A. D.** 1924. Insects affecting forest resources and shade trees. The southern pine beetle. Annu. Rep. USDA for the year 1923. Rep. Sec. Agric. Rep. of Chiefs Wash. Gov. Print. Off. p. 411. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). OUTBREAKS In late 1922, a serious outbreak of the southern pine beetle was threatening southern Virginia. Through demonstration control work the problem should be solved.

493. **HOWARD L. O.** 1906. Report of the entomologist. USDA Annu. Rep. Dep. Agric. Bur. Entomol. p. 14. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Reports on control efforts of the southern pine beetle.

494. **HOWARD L. O.** 1912. Report of the entomologist for 1912. USDA Annu. Rep. Dep. Agric. Bur. Entomol. p. 22-23. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL Reports on direct control of southern pine beetle through cutting and burning are presented.

495. **HOWARD L. O.** 1920. Report of the entomologist. USDA Bur. Entomol. p. 26-27. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW A report on the status of southern pine beetle populations in the Southeast in 1920.

496. **HOWARD L. O.** 1924. Report of the entomologist. USDA Bur. Entomol. p. 26. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The southern pine beetle was epidemic from Virginia to East Texas.

497. **HOWARD L. O.** 1927. Report of the entomologist. USDA Bur. Entomol. p. 24-25. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST RESISTANCE, WEATHER RELATIONSHIPS Southern pine beetles were found to infest drought-weakened trees. Overwintering mortality occurred at zero degrees Fahrenheit.

498. **HOWE V. K., OBERLE A. D., KEETH T. G., GORDON W. J.** 1971. The role of microorganisms in the attractiveness of

lightning-struck pines to southern pine beetles. Ser. in the Biol. Sci. No. 9:1-44, West Ill. Univ. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Candida* spp. *Penicillium* spp. *Bacillus* spp.). ATTRACTANTS, HOST SELECTION, PATHOGENS, BACTERIA, LIGHTNING, LIGHTNING Southern pine beetle associations with pines struck by lightning are reviewed. Yeasts and other microorganisms associated with southern pine beetle in these trees were identified. A total of 118 cultures from beetle galleries yielded 203 isolates of bacteria, yeasts and hyphal fungi. A total of 42 cultures from wounds of eight lightning-struck loblolly pines yielded 577 isolates of bacteria, yeasts and hyphal fungi. Yeasts and bacteria were isolated most frequently from samples in the first three weeks. After three weeks, hyphal fungi predominated. These associated microoganisms may enhance pine attractiveness to bark beetles.

499. **HSE S. H. H.** 1964. Biological studies of mites associated with bark beetles. M.S. Thesis, La. State Univ., Baton Rouge, La. 31 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus.* ACARINA: MACROCHELIDAE; *Macrocheles* n. sp. PARASITIDAE; *Eugamasus* n. sp. UROPODIDAE; *Leiodinychus* n. sp.). PREDATOR, PARASITES, CONTROL-BIOLOGICAL, TRAPS AND CAGES, MITES, NEMATODES Species of mites associated with *Dendroctonus frontalis* included new species in the Families Macrochelidae, Parasitidae and Cloropodidae. *Macrochelus* n. sp. (Macrochelidae) fertilized eggs become females while unfertilized eggs become males. *Eugamasus* n. sp. (Parasitidae) preys on nematodes and mites found in beetle galleries. *Leiodinychus* n. sp. (Uropodidae) deutonymphs are attached to beetles by an anal pedicel; the pedicel is thought to aid in dispersal. Life histories of the three mites are discussed.

500. **HUGHES P. R.** 1973. *Dendroctonus*: Production of pheromones and related compounds in response to host monoterpenes. Z. Angew. Entomol. 73:294-312. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). BEHAVIORAL CHEMICALS, ATTRACTANTS The production of *Dendroctonus* pheromones and related compounds in response to host monoterpenes is described. The production of *trans*-verbenol was linearly related to the exposure period of female *D. brevicomis* to *alpha*-pinene. Ingestion of terpenes is not necessary for their production, and a non-specific oxidation mechanism of cyclic compounds at the allylic carbons, common in *Dendroctonus*, is suggested. The volatiles produced by the beetles in the presence of host monoterpenes are products of terpene metabolism which are eliminated from the body through excretion. The production of pheromones in response to host compounds, feeding, and mating is discussed.

501 **HUGHES P. R.** 1975. Pheromones of *Dendroctonus*: Origin of *alpha*-pinene oxidation products present in emergent adults. J. Insect Physiol. 21:687-691. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*). EMERGENCE, BEHAVIORAL CHEMICALS, ATTRACTANTS Experimentation showed that larvae and adults of *Dendroctonus frontalis* and *D. terebrans* metabolize *alpha*-pinene, to produce oxidation products including *trans*-verbenol; this was not found in the pupal stage. However, all pupae do conjugate some form of the terpene molecule which is later metabolized by the adult to produce previously identified oxidation products found in emergent beetles. Male *D. frontalis* also are capable of producing verbenone from *alpha*-pinene, a possible evolutionary specialization in the field of chemical communication in bark beetles. It is possible that other terpenes are metabolized in the same manner in other *D.* spp. and related genera.

502. **HUGHES P. R.** 1976. Response of female southern pine beetles to the aggregation pheromone frontalin. Z. Angew. Entomol. 80:280-284. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEX-RATIOS, BEHAVIORAL CHEMICALS, ATTRACTANTS, TRAPS AND CAGES A large trapping surface and slow pheromone release were used in a sex ratio study to determine differential rates of attraction. The ratio obtained through frontalin baiting showed nearly equal numbers of males and females; this is similar to what occurs under natural conditions. Differences occurred in the distance orientation of the two sexes with males landing close to the pheromone source and females at a distance. When sampling sex ratios, it is important to pay special attention to trap size, rate of pheromone release, and the average threshold for response to landing stimuli.

503. **HUNTER P. E., MOSER J. C.** 1968. *Pseudoparasitus thatcheri* n. sp. (Acarina: Dermanyssidae, Laelapinae) associated with southern pine beetles. Fla. Entomol. 51(2):119-123. (COLEOPTERA: SCOLYTIDAE; ACARINA: DERMANYSSIDAE; LAELAPINAE; *Psuedoparasitus thatcheri*). ADULT, PREDATOR, PARASITES, COMMENSALISM AND SYMBIOSIS, MITES Taxonomic descriptions of adult and nymphal stages of *Pseudoparasitus thatcheri*, a mite in Louisiana which is associated with several bark beetles, are given. Possible generic placement is discussed. Brief portions of the life cycle are included.

504. **HURLBUTT H. W.** 1967. *Digamasellid* mites associated with bark beetles and litter in North America. Acarologia 9:497-534. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis* ACARINA: DIAMASELLIDAE; *Digamasellus* spp., *Longoseius* spp.). TAXONOMY, MITES Eight new species of Digamasellidae from North America are described and figured. Many species were from *Dendroctonus frontalis* galleries.

505. **HYCHE L. L.** 1965. Chemicals in forest insect control - (insecticides, chemosterilants, attractants). Fourteenth Annu. For. Symp.: Insects in South. For., 1965 La. State Press. Baton Rouge, La. 73-79. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-GENERAL, CONTROL-CHEMICAL, REVIEW Attractants as control agents are presented.

506. **HYCHE L. L.** 1975. The southern pine beetle. Ala. Agric. Exp. Stn. Highlights Agric. Res. 22:14. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, REVIEW Southern pine beetle damage, taxonomic characteristics of all life stages, a brief life history, host-insect selection, and some control methods are outlined.

507. **HYCHE L. L.** 1976. Southern pine beetle - a formidable foe. Ala. For. Prod. 19(7):11-13. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW Brief description of the southern pine beetle problem.

508. **HYCHE** L. L. 1977. Vigorous trees may "pitchout" attacking southern pine beetles. Ala. Agric. Exp. Stn. Highlights Agric. Res. 24:6. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST RESISTANCE, SURVEY AND DETECTION Southern pine beetle spot expansion in a 12 year old loblolly pine stand in Lee County, Alabama, is described.

509. **HYLAND J.** 1971. Southern pine beetle in Alabama. Ala. For. Prod. 15:5-6. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, SURVEY AND DETECTION, CONTROL-CULTURAL, WEATHER RELATIONSHIPS The southern pine beetle was first epidemic in central Alabama in 1960-1961. The epidemic was stopped by an extremely cold winter. Describes life history and damage of southern pine beetle. The southern pine beetle first attacks weakened damaged trees and spreads over large areas. Recommends salvaging beetle spots and cutting a buffer strip of 40 to 70 feet; this reduces the possibility of 'breakouts.'

510. **HYNUM B. G.** 1980. Changes in the sex ratio of *Dendroctonus frontalis* (Coleoptera: Scolytidae) on *Pinus taeda* during the attack process. Can. Entomol. 112:1317-1318. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEX-RATIOS, TRAPS AND CAGES The ratio of attacking females to males decreased as pines were colonized.

511. **HYNUM B. G.** 1980. Models of the attack process of the southern pine beetle on individual loblolly pines. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 94-97. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS, MODELING, MISCELLANEOUS TECHNIQUES Two simple mathematical models showing the

characteristics of the attack process of the southern pine beetle (*Dendroctonus frontalis*) are given. One relates new attacks to cumulative old attacks; the second relates attraction to cumulative old attacks. Three parameters were used in model development. They are peak number of landing beetles per gallery start, peak gallery initiation rate, and final attack density. Factors which may influence parameter values are discussed.

512. **IFJU G., FERGUSON P. C., ODERWALD R. G.** 1977. Pulping and papermaking properties of southern pine harvested from beetle-infested forests. 1977 TAPPI For. Biol. Wood Chem. Conf. June 20-22, Madison, Wisconsin. p. 169-176. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION Seventy-five bark beetle-infested trees cut and chipped, from the Virginia Piedmont Coastal Area were evaluated for use as pulp and paper products. Trees were segregated according to the time they had been left dead on the stump. Kraft pulp yield was not affected by allowing the trees to remain on the stump for as long as three years. Canadian Standard Freeness was found to increase significantly, at high beating times as deterioration increased. However, tearing resistance decreased as soon as six months. Tensile strength increased slightly after six months and then began to decrease significantly. In general, utilization for pulp and paper appears to be feasible for as long as 24 months after standing dead on the stump.

513. **IFJU G., ODERWALD R. G., FERGUSON P. C., HEIKKENEN H. J.** 1979. Evaluation of beetle-killed southern pine as raw material for pulp and paper. TAPPI 62:77-80. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION Bark beetle-infested trees, cut and chipped, from the Virginia Piedmont and Coastal Region, were evaluated for use as pulp and paper products. Trees were segregated according to the time they had been left dead on the stump. No drop in kraft pulp yield was found as compared to healthy green trees. Tearing resistance was found to decrease from zero to six months. Tensile strength increased only slightly, then increased past six months. Trees were observed to be feasible for utilization as long as 24 months standing dead on the stump.

514. **JACKSON L. W. R., THOMPSON G. E., LUND H. O.** NO DATE. Forest diseases and insects of Georgia's trees. Ga. For. Comm. 40 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*). SURVEY AND DETECTION The insect and disease pests of forest trees in Georgia are summarized.

515. **JACOBSON M.** 1972. Insect sex pheromones. Acad. Press, New York. p. 73-74,90,110,146,198-199,236,251-253,281. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, REVIEW Reviews pheromones in *Dendroctonus frontalis*, including frontalin.

516. **JOHNSON P. C.** 1977. Sex-ratio estimation, sequential sampling, and the programmable pocket calculator. Bull. Entomol. Soc. Am. 23:251-254. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, SEX-RATIOS Sequential sampling was an efficient technique for estimating in a binomial population. Johnson adapted graphs for sequential sampling for a programmable calculator.

517. **JOHNSON P. C., COSTER J. E.** 1978. Probability of attack by southern pine beetle in relation to distance from an attractive host tree. For. Sci. 24:574-580. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, ATTRACTANTS, FLIGHT Patterns of southern pine beetle attack for two infestations (one large with many simultaneous pheromone sources, the other intermediate in size with few simultaneous sources of pheromone) indicate an exponential decrease in probability of attack (PA) of host trees as a function of distance (X) from active pheromone sources (trees currently under attack). The slope coefficients and correlating coefficients for log transformed linear regressions of PA or X are related to the size of the infestation and the number of simultaneous pheromone sources.

518. **JOHNSON P. C., COSTER J. E.** 1979. Techniques for evaluating the influence of behavioral chemicals on dispersion of the southern pine beetle within infestations. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 18-26. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TRAPS AND CAGES, STATISTICAL METHODS The parameters of mean crowding (MC) and mean quadrant density (M) can be estimated to provide a means for comparison to evaluate the influence of behavioral chemicals on southern pine beetle within infestations. Trapping grids are used to estimate the two parameters. The parameters are then used to quantify experimentally induced dispersion as a means of estimating control effectiveness. Daily dispersion patterns are quantified by utilizing the index of patchiness (MC/M). Limitations on experimental design and cost effectiveness are also discussed.

519. **JOHNSON P. C., COSTER J. E.** 1980. Seasonal and behavioral chemical effects on dispersion of the southern pine beetle within infestations. *In*, Proc. Second IUFRO Conf. On "Dispersal of For. Insects.: Eval. Theory and Manage. Implications." Sandpoint, Idaho, Aug. 1979, A. A. Berryman and L. Safranyik, Eds. p. 173-193. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, AGGREGATION, BEHAVIORAL CHEMICALS, STATISTICAL METHODS, MODELING Dispersion of the southern pine beetle, *Dendroctonus frontalis*, was monitored within infestations by means of sticky traps and was quantified by comparison of mean crowding (M) to mean (M) regressions. Aggregation of dispersion patterns is compared on a seasonal basis. The introduction of behavioral chemicals was shown to have no apparent effect (95% prediction limit) on the M-M comparison.

520. **JONES A. S., HASTINGS F. L.** 1981. Soil microbe studies. *In*, Field and laboratory evaluations of insecticides for southern pine beetle control. Hastings, F. L. and J. E. Coster, Eds. USDA For. Serv. South. For. Exp. Stn. Gen. Tech. Rep. SE-21, Asheville, N. C. p. 13-14. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, MISCELLANEOUS TECHNIQUES Studies were conducted to test the effect of chlorpyrifos and fenitrothion on soil microbial populations, metabolism of fenitrothion by forest soil fungi, and metabolism of chlorpyrifos by pure cultures of forest soil fungi.

521. **JONES A. S., HASTINGS F. L., KISLOW C. J.** 1980. Evaluation of 12 insecticides for remedial efficacy against southern pine beetle adults. J. Econ. Entomol. 73:736-738. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Twelve insecticides were tested for their effectiveness against the southern pine beetle. At 1 and 2% chlorpyrifos, chlorpyrifos-methyl, fenitrothion, pirimiphos-ethyl, etrimphis, and a microencapsulated form of phosmet were better than the currently recommended insecticide, lindane, at its registered dose. All insecticides tested (except carbophen othion) were at least as good as lindane. Only 61% of emerging southern pine beetles were killed by lindane, whereas six test treatments killed more than 90% of emerging southern pine beetles.

522. **JONES G. D., FORD J. E.** 1953. Southern pine beetle. N. C. State Coll. Ext. Folder No. 100. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). LIFE HISTORY-GENERAL, CONTROL-GENERAL Briefly summarizes life history and control of the southern pine beetle. Chemical control by BHC is recommended.

523. **JOYE L. G.** 1976. Incidence of *Contortylenchus brevicomi* (Massey) Rhum in southern pine beetle populations from the southeastern United States. M. S. Thesis, Univ. Fla., Gainesville, Fla. 29 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Contortylenchus brevicomi, Contortylenchus terebranus*). EGG, LARVAE, PUPAE, ADULT, FECUNDITY, CONTROL-BIOLOGICAL, PARASITES, NEMATODES Southern pine beetle populations from 17 locations were examined for infection by nematodes. *Contortylenchus brevicomi* was present in 15 of the locations.

Rate of infection for most populations was 10-20%. Mature southern pine beetles contained adult parasitic females, larvae, eggs, and some individuals contained thousands of larvae and eggs. The southern pine beetle is probably infected during its pupal stage.

524. **JOYE L. G., PERRY V. G.** 1976. Incidence of *Contortylenchus* spp. in southern pine beetle populations from the southeastern United States. J. Nematol. 8:291. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. NEMATODAE; *Contortylenchus* spp.). PREDATOR, PARASITES, NEMATODES Adult, larval and pupal southern pine beetles were examined for the presence of internal nematode parasites of the genus *Contortylenchus* in the southern United States. In large samples incidence ranged from 12-24% in small samples incidence was only noted. Two species were noted parasitizing with the numbers of each increasing with beetle age.

525. **JUMP B. J., TSAO C. H.** 1972. Effectiveness and efficiency of controlling the southern pine beetle by spraying standing trees with BHC. Bull. Ga. Acad. Sci. 30:55. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Two methods of spraying trees infested with the southern pine beetle are discussed; one method involves spraying BHC and fuel oil on standing trees, the other involves felling the tree and then spraying. Control was found to be only seven percent better when the trees were felled. Averaging man hours needed and gallons of insecticide used showed that spraying standing trees was 21 times more efficient than felling first.

526. **JUMP B. J., TSAO C. H.** 1973. Control of southern pine beetles by spraying standing and felled trees with BHC. J. Ga. Entomol. Soc. 8:203-209. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CHEMICAL Two methods of controlling the southern pine beetle chemically using BHC are discussed. One is simply to spray standing trees; the other includes felling then spraying. Both methods gave more than 99% control. Treating standing trees was 16 times faster but required about twice as much chemical.

527. **KALKSTEIN L. S.** 1974a. A method to determine relationships between climate and outbreaks of the southern pine beetle (*Dendroctonus frontalis* Zimm.). Ph.D. Diss., La. State Univ., Baton Rouge, La. 130 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, WEATHER RELATIONSHIPS Two models were developed to evaluate the relationship between southern pine beetle outbreaks and temporal changes in climatic variables. In most cases southern pine beetle activity was related to moisture surplus and late winter evapotranspiration. Activity was inversely related to moisture deficit and summer evapotranspiration.

528. **KALKSTEIN L. S.** 1974b. The effect of climate upon outbreaks of the southern pine beetle. C. W. Thornthwaite Assocs. Lab. of Climatology, Elmer, New Jersey, Publ. in Climatology 27(3):1-65. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Kalkstein hypothesized that the frequency and severity of outbreaks of the southern pine beetle are regulated by temporal variations in climate. A technique designed by C. W. Thornthwaite was more satisfactory in identifying climate components than was a technique by T. C. R. White. Advantages of Thornthwaite's technique were: 1) use of soil moisture, 2) inclusion of actual evapotranspiration estimates, 3) evaluation of moisture surplus and deficits, and 4) evaluation of site information related to poorly drained sites. A final statistical model suggested these relationships: 1) excessive moisture appears to increase the probability of a southern pine beetle outbreak; 2) moisture surpluses have a greater effect on southern pine beetle outbreaks in East Texas than Louisiana; 3) moisture deficit is of lesser significance than surplus; 4) as the deficit value increases, southern pine beetle activity decreases; 5) winter potential evapotranspiration values above normal appear to promote conditions necessary for intense southern pine beetle activity the following summer; and 6) intense summer heat is detrimental to southern pine beetle activity. Kalkstein makes recommendations for use of weather data and integrated research.

529. **KALKSTEIN L. S.** 1976. Effects of climatic stress upon outbreaks of the southern pine beetle. Environ. Entomol. 5:653-658. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. STATISTICAL METHODS, MODELING, WEATHER RELATIONSHIPS Monthly tabulations of southern pine beetle activity in East Texas were correlated with various climatic conditions derived from the Thornthwaite water balance to develop a predictive insect activity technique based upon climatic conditions of the past. Generally, the intensity of insect activity is directly related to moisture surplus and deficit, and inversely related to summer potential evapotranspiration. The model worked in predicting a July 1973 southern pine beetle outbreak. It is thought that models like this are most important for future silvicultural planning.

530. **KALKSTEIN L. S.** 1981a. An improved technique to evaluate climate-southern pine beetle relationships. For. Sci. 27:579-589. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING, WEATHER RELATIONSHIPS The effect of climate on the southern pine beetle was evaluated on 18 years of data in East Texas. Three water balance variables and three weather variables accounting for climatic extremes were included. Southern pine beetle/climate models were constructed for individual months. An important lag time differential between climate and spring versus summer month outbreaks was uncovered. The developed model predicted variations in outbreaks for 1958-1960 and 1979-1980.

531. **KALKSTEIN L. S.** 1981b. Differential response of loblolly pines to climatic stress. Prof. Geogr. 33:122-128. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, WEATHER RELATIONSHIPS Differences in the interregional response of loblolly pines to moisture stress is examined. Pines in Texas are weakened and increasingly susceptible to southern pine beetle attack during periods of extreme moisture surplus. Louisiana pines are rendered more susceptible to attack during periods of extreme moisture deficits. Intraspecies response to climatic stress appears to be dependent on frequency of the climatic event and also spatially variable.

532. **KEEN F. P.** 1950. Pine bark beetles. USDA Yearb. of Agric. 1949. p. 427-432. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Dendroctonus monticolae*, *Dendroctonus ponderosae*, *Dendroctonus jeffreyi*, *Dendroctonus valens*, *Dendroctonus terebrans*, *Ips* spp.). LIFE HISTORY-GENERAL, ECOLOGICAL DISTRIBUTION, HOST SELECTION, FIRE, REVIEW, WEATHER RELATIONSHIPS, STAND CONDITIONS A review of the life history and habits of the bark beetles.

533. **KELLY M. W., BAREFOOT J. E., SWINT W. H., LEVI M. P.** 1982. Utilization of southern pine beetle-killed trees for hardboard and particleboard. For. Prod. J. 32(3):33-39. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Products from beetle-killed trees can be made if there is a mix of wood from healthy trees to minimize effects. Hardboards from beetle-killed pines met industry standards except for linear expansion.

534. **KERR E.** 1957. Battle of the beetle. Forests and People, Second Quarter, p. 36-38. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, SURVEY AND DETECTION Describes survey and detection for southern pine beetle. Control measures include cutting down infested timber and spraying logs with benzene hexachloride and No. 2 diesel oil solution. Southern pine beetle was just building up in Louisiana.

535. **KETCHAM D. E.** 1964a. Aerial survey plan for sampling bark beetle populations. Proc. Third Annu. Work Conf., 1964. USDA For. Insect and Dis. Conf., Div. State and Priv. For., Atlanta, Ga. p. 81-101. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Aerial survey plans for bark beetle populations include flight plans, proper detection methods, and coordination with ground check personnel.

536. **KETCHAM D. E.** 1964b. Southern pine bark beetles. Int. Shade Tree Conf. Proc. p. 56-60. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-

GENERAL Ketcham describes life history and chemical controls (BHC) for the southern pine beetle.

537. **KETCHAM D. E., SHEA K. R.** 1977. USDA Combined Forest Pest Research and Development Program. J. For. 75:404-407. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, REVIEW, INTEGRATED PEST MANAGEMENT The authors present a brief overview of the USDA Combined Forest Pest Research and Development Program. Organization of the administration, planning, and funding of the program is discussed. Progress and accomplishments are briefly presented.

538. **KETCHAM D. E., SHEA K. R.** 1982. Research decision-making in a concerted research program--USDA's combined forest pest program. *In*, Increasing forest productivity. Proc. 1981 Soc. Am. For. Natl. Meet., Orlando, Fla. p. 308-310. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). INTEGRATED PEST MANAGEMENT The program planning and organization of large-scale pest management programs are reviewed.

539. **KING E. W.** 1972. Rainfall and epidemics of the southern pine beetle. Environ. Entomol. 1:279-285. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS, DISTRIBUTION, WEATHER RELATIONSHIPS Monthly rainfall preceding known epidemics of the southern pine beetle in Texas, Mississippi, Alabama, Georgia, Florida, South Carolina, and North Carolina was compared to that of non-epidemic years, for the period 1910-1962. Epidemic years were characterized by: 1) high winter rainfall in Texas, 2) low summer rainfall in Georgia, and 3) high spring and low early summer rainfall in North and South Carolina. Statistics for other states were not conclusive. Rainfall after an epidemic did not affect the epidemic.

540. **KINN D. N.** 1976. Key to mites commonly associated with the southern pine beetle. USDA Res. Note SO-214. 11 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, CONTROL-BIOLOGICAL, MITES A method for preparing mites for microscopic examination is given along with a simple illustrated key to identify the 15 most common species of mites usually associated with the southern pine beetle. This is a guide to identification for research workers untrained in Acarology.

541. **KINN D. N.** 1978. Diel emergence patterns of the southern pine beetle (*Dendroctonus frontalis* Zimm.). J. Ga. Entomol. Soc. 13:80-85. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, EMERGENCE, WEATHER RELATIONSHIPS Bolts of loblolly pine infested with the southern pine beetle were kept under controlled and ambient conditions to determine diel emergence patterns; it appeared southern pine beetle is governed by an endogenous rhythm. During the spring and summer months emergence peaked in mid-afternoon but was not influenced by temperature or relative humidity. Winter emergence was found to be temperature dependent. It is thought that barometric pressure may influence emergence.

542. **KINN D. N.** 1979. Three methods of sampling mites phoretic on bark beetles: A comparison. Can. Entomol. 111:491-494. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, TRAPS AND CAGES, MISCELLANEOUS TECHNIQUES, MITES When sampling phoretic mites on bark beetles inhabiting large trees, emergence traps provide more reliable mite counts than either removal of the bolts or removal of bark discs. When a large sample from a small tree is required, bolt removal is preferred. Emergence traps or bolts are preferable because: 1) mites are not left on the xylem, 2) fewer die from desiccation during rearing, 3) fewer non-phoretic stages accumulate in the collecting medium and 4) fewer mites are lost during transportation and rearing.

543. **KINN D. N.** 1980. Mutualism between *Dendrolaelaps neodisetus* and *Dendroctonus frontalis*. Environ. Entomol. 9:756-758. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Dendrolaelaps neodisetus*, *Contortylenchus brevicomi*). RADIOGRAPHY, MITES, NEMATODES The relationship between *D. frontalis* and *Dendrolaelaps neodisetus* is apparently mutualistic. The mite uses the beetle to escape a deteriorating habitat and reach a fresh food source. In turn, the beetle benefits by the removal of the nematode *C. brevicomi*.

544. **KINN D. N., MILLER M. C.** 1981. A phloem sandwich unit for observing bark beetles, associated predators, and parasites. USDA South. For. Exp. Stn. Res. Note SO-269 South. For. Exp. Stn., New Orleans, La. 3 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). TRAPS AND CAGES, REARING A phloem sandwich that permits observation of parent beetles, their brood, and their associated parasites or predators is described. Multiple beetle pairs may be introduced.

545. **KINN D. N., STEPHEN F. M.** 1981. The incidence of endoparasitism of *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae) by *Contortylenchus brevicomi* (Massey) Ruhm (Nematoda: Sphaerulariidae). Z. Angew. Entomol. 91:452-458. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. NEMATODA; *Contorylenchus brevicomi*). NEMATODES, PARASITES, FLIGHT, SEASONAL OCCURRENCE Adults of *Dendroctonus frontalis* emerging from lower and middle sections of infested bolts usually had a higher incidence of endoparasitism by *Contortylenchus brevicomi* than beetles emerging from the upper bole. Endoparasitism was greater in emerging females than males.

546. **KINN D. N., WITCOSKY J. J.** 1977. The life cycle and behaviour of *Macrocheles boudreauxi* Krantz. Z. Angew. Entomol. 84:136-144. (ACARINA: MESOSTIGMATA; *Macrocheles boudreauxi*; COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, PREDATOR, PARASITES, COMMENSALISM AND SYMBIOSIS, MITES *Macrocheles boudreauxi* Krantz has phoretic association with bark beetles, including the southern pine beetle. This paper describes the larval stages, diet, and life cycle of *M. boudreauxi*. Taxonomy is included for all stages.

547. **KINN D. N., WITCOSKY J. J.** 1978. Variation in southern pine beetle attack height associated with phoretic uropodid mites. Can. Entomol. 110:249-251. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, MITES, FLIGHT Frontalin-baited bucket traps were placed at three, six, and nine meters on the boles of loblolly pines to investigate southern pine beetle-uropodid mite relationships. A total of 8475 beetles were caught; 36.3% of all caught carried uropodids or their pedicels. Since beetles caught at lower points on the tree generally carried more pedicels, it is thought beetle flight is influenced by the presence of phoretic mites. It is noted that reemerging parent beetles can be differentiated from brood adults by the color of the mite pedicels they carry.

548. **KINZER G. W., FENTIMAN A. F., PAGE T. F., FOLTZ R. L., VITE J. P., PITMAN G. B.** 1969. Bark beetle attractants: Identification, synthesis and field bioassay of a new compound isolated from *Dendroctonus*. Nature (Lond.) 221:477-478. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-BIOLOGICAL, MORPHOLOGY AND PHYSIOLOGY The chemical isolation and actual field responses by beetles to the organic compound 1,5-dimethyl-6,8-dioxabicyclo [3,2,1] octane, which is found naturally in the hindguts of both southern pine beetle (*Dendroctonus frontalis*) and *D. brevicomis*. This compound seems to be principally responsible for mass aggregation of the southern pine beetle. The trivial name 'frontalin' was proposed.

549. **KIRBY J.** 1954. Death strikes the woods. For. Farmer 13(6):5,10-11. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL Discusses 1952 southern pine beetle epidemic in southwest Mississippi. The epidemic developed following an ice storm. The storm killed most of the woodpeckers. *Ips* and black turpentine beetles were also present. Products were salvaged and areas were chemically treated with benzene hexachloride. Southern pine beetles were most destructive in heavy, dense stands of pure pines.

550. **KLIEFOTH R. A., VITÉ J. P., PITMAN G. B.** 1964. A laboratory technique for testing bark beetle attractants. Contrib. Boyce Thompson Inst. 22:283-290. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, MISCELLANEOUS TECHNIQUES A technique is described for testing the attractiveness and arrestive potential of chemicals isolated from bark beetle infested pines. A sophisticated olfactometer chamber is described in which light, temperature, and humidity can be controlled. Each species of beetle tested preferred the attractant of its own species. A moist atmosphere was most conducive for beetle response.

551. **KNELL J. D., ALLEN G. E.** 1978. Morphology and ultrastructure of *Unikaryon minutum* sp. n. (Microsporida: Protozoa), a parasite of the southern pine beetle, *Dendroctonus frontalis*. Acta Protozoologica 17:271-278. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Unikaryon minutum*). PREDATOR, PARASITES, PATHOGENS A new species of microsporida, *Unikaryon minutum*, collected from the southern pine beetle (*Dendroctonus frontalis*) is described. Spores were observed to be uninucleate arising from sporonts (in insolation) through binary fission. As is characteristic of microsporidium, there was an absence of a cyst, xenoma, and parasitophorous vesicle. The microsporidium infects the muscle, malphigian tubules, fat bodies and the midgut tissue.

552. **KNOX K. A., SCHROEDER W. L.** 1963. Pine beetle outbreak. Va. For. 81:8-9,18. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL A general description and review of the life history of the southern pine beetle is discussed along with recommendations for controlling infestations. Historic outbreaks of the beetle in Virginia are discussed and current conditions (1962) and the possibility of future outbreaks are assessed.

553. **KNULL J. W.** 1934. The southern pine beetle in Pennsylvania (*Dendroctonus frontalis* Zimm.). J. Econ. Entomol. 27:716-718. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, ECOLOGICAL DISTRIBUTION, SEASONAL OCCURRENCE, POPULATION DYNAMICS, AGGREGATION, DISTRIBUTION, SURVEY AND DETECTION, VERTEBRATES Knull comments on the general occurrence of southern pine beetle infestations in Pennsylvania during the years 1930 through 1933. Climatological records were cited and briefly related to infestations possibly caused by tree stress. Examinations of several infestatons throughout the state revealed that southern pine beetle attacked pitch pine, shortleaf pine, table mountain pine, white pine, and Virginia scrub pine. Woodpeckers were noted to have severely reduced developing brood populations of southern pine beetle. *Acanthocinus nodosus* larvae were observed to be unusually abundant at the basal portion of many thick-barked hard pines infested by southern pine beetle.

554. **KOENIGS J. W., BEERS W. L. JR.** 1980. Integrated forest pest management–an industrial perspective. *In*, For. Pest Manage. 12th Spring Symp., Fla. Sec., Soc. Am. For., June 3-4, 1980, Univ. Fla. p. 79-94. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). CONTROL-GENERAL, INTEGRATED PEST MANAGEMENT The authors define IFPM, relating the program to user groups, and several pests of southern pines, including fusiform rust, annosus root-rot, brown-spot needle blight, littleleaf disease, pine bark beetles, Pales weevil and tip moth. Control options are discussed.

555. **KOWAL R. J.** 1950. Insects commonly attacking forest trees and unseasoned timber in the southern states. For. Farmer 9(5):28-31. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). SURVEY AND DETECTION A discussion of insects affecting the southern forest is presented. Tables of insects along with their damage and controls are included.

556. **KOWAL R. J.** 1953. Insects–forest enemy No. 1? For. Farmer 12(10):5-7. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). A general discussion of damage caused by southern pine beetle, black turpentine beetle and the *Ips* beetles is presented. Methods of control are given.

557. **KOWAL R. J.** 1955. Where we stand in our fight against forest insects. For. Farmer 14(10):4-6. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, ECONOMICS, IMPACT A general review of forest conditions in the South with regard to insect losses in the early 1950's is presented. The article points out the severity of losses and emphasizes that forest protection from insects is far below the required effort. The author recommends fundamental research in forest entomology, at federal and state levels and at educational institutions, pointed toward determining the cause of insect pest epidemics.

558. **KOWAL R. J.** 1956. Insects commonly attacking forest trees and products in the south. For. Farmer Manu. Ed. Fourth Ed. p. 22-29. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). CONTROL-CHEMICAL, LIFE HISTORY-GENERAL A general discussion of major forest pests is presented with attention given to control. A key of southern pine insects is included. See also Third Ed. p. 22-29.

559. **KOWAL R. J.** 1957. We can check the silent killers! For. Farmer 17(3):6-7,12,18. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). CONTROL-CHEMICAL, REVIEW Controls for the southern pine beetle include the chemical, benzene hexachloride (0.25 to 0.50%) in No. 2 diesel fuel and prompt salvage.

560. **KOWAL R. J.** 1958. Meeting the problem of tree killing insects. For. Farmer Manu. Ed. 18(7):38-45. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*. CERAMBYCIDAE; *Monochamus titillator*). CONTROL-CHEMICAL, LIFE HISTORY-GENERAL A general discussion of major forest pests is presented with attention given to research needs and control. A key of southern pine insects is included.

561. **KOWAL R. J.** 1960. Southern pine beetle. USDA For. Serv. For. Pest Leafl. No. 49. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CHEMICAL Life history and controls (BHC, felling and peeling) are summarized.

562. **KOWAL R. J.** 1961. Common bark beetle found in the Southern States. For. Bull. No. 67:1-2. (COLEOPTERA: SCOLYTIDAE; *Ips* spp., *Dendroctonus* spp.). LIFE HISTORY-GENERAL, CONTROL-GENERAL General key to bark beetles in the southern United States.

563. **KOWAL R. J.** 1962. Forest insects - the problem and how to meet it. For. Farmer Manu. Ed. 21(7):64-71. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Dendroctonus valens*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). CONTROL-GENERAL, SURVEY AND DETECTION A general discussion of major forest insect detection and control. A key to insects attacking southern pine is included.

564. **KOWAL R. J.** 1964. Forest insects - the problem and how to meet it. For. Farmer Manu. Ed. 23(7):25-31. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Dendroctonus valens*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). CONTROL-GENERAL, SURVEY AND DETECTION A general discussion of major forest insect detection and control. A key to insects attacking southern pine is included. See also 14(7):98-105, 20(7):70-77.

565. **KOWAL R. J., EBEL B. H.** 1971. Insects attacking forest trees in the South. For. Farmer Manu. Ed. 30(7):89-95. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Dendroctonus valens*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). LIFE HISTORY-GENERAL, IMPACT, SURVEY AND DETECTION A brief discussion of pest problems is given along with a key to insects attacking southern forest trees.

566. **KOWAL R. J., EBEL B. H.** 1977. Insects attacking forest

trees in the South. For. Prod. Dir. 77 ed. p. 137-143. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Dendroctonus valens, Ips* spp.). LIFE HISTORY-GENERAL The authors list in chart form the insects attacking forest trees in the southern states. The chart headings include: name of insect, host, type of damage, habits and life history, and means of recognition of injury and insect.

567. **KOWAL R. J., ROSSELL H.** 1958. Beetles in your pines? How good cutting practices and management stop beetles from killing your timber. USDA For. Serv. Southeast. For . Exp. Stn., Asheville, N. C. 28 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*). CONTROL-CULTURAL, CONTROL-CHEMICAL Cultural and chemical controls for bark beetles are presented in an easy-to-read manual.

568. **KRANTZ G. W.** 1965. A new species of *Macrocheles* (Acarina: Macrochelidae) associated with bark beetles of the genera *Ips* and *Dendroctonus*. J. Kans. Entomol. Soc. 38:145-153. (COLEOPTERA: SCOLYTIDAE; *Ips* spp. *Dendroctonus* spp. ACARINA: MACROCHELIDAE; *Macrochelus boudreauxi*). ECOLOGICAL DISTRIBUTION, DISTRIBUTION, TAXONOMY, COMMENSALISM AND SYMBIOSIS, MITES The male and female protonymph and deutonymph of *Macrocheles boudreauxi* are described. Those described were collected from bark beetles and bark beetle galleries in the southern United States. Intraspecific variation and sculpturing of the female sternal shield and sculpturing in the armature of leg IV in the male are discussed. Diagrams are given. The species is believed to be a member of the species-group *subbadius*.

569. **KROLL J. C., CONNER R. N., FLEET R. R.** 1980. Woodpeckers and the southern pine beetle. USDA Comb. For. Pest Res. and Dev. Prog. Agric. Handb. No. 564. 23 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, VERTEBRATES, CONTROL-BIOLOGICAL Four species of woodpeckers, (*Picoides villosus, Picoides pubescens, Dryocopus pileatus, Melanerpes carolinus*), commonly associated with southern pine beetle, *Dendroctonus frontalis* Zimm., infestations are presented. Identification and habits of each are described. Impact of these woodpeckers on pine beetle populations is discussed. An integrated approach to management practices that favor higher populations of predacious woodpeckers is presented.

570. **KROLL J. C., FLEET R. R.** 1979. Impact of woodpecker predation on over-wintering within-tree populations of the southern pine beetle (*Dendroctonus frontalis*). *In*, The Role of Insectivorous Birds In Forest Ecosystems, Dickson, J.G., Conner, R.N., Fleet, R.R., Kroll, J.C., and Jackson, J.A., Eds. Acad. Press, Inc., N.Y. p. 269-281. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, VERTEBRATES, POPULATION DYNAMICS, CONTROL-BIOLOGICAL, CONTROL-CULTURAL Woodpecker predation was studied on within-tree populations of southern pine beetles from November 1975-February 1976. Results indicated that significant impact on pupal and brood adult stages occurred, and feeding was centered around the mid-bole. Woodpecker feeding paralleled increases in southern pine beetle predators and parasites. Downy, hairy and pileated woodpeckers seemed particularly attracted to beetle areas. It is concluded that woodpeckers affect beetle populations to a greater extent than any other known agent and should be considered in any integrated pest management system.

571. **KROLL J. C., REEVES H. C.** 1978. A simple model for predicting annual numbers of southern pine beetle infestations in East Texas. South. J. Appl. For. 2:62-64. (COLEOPTERA:SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, WEATHER RELATIONSHIPS From 1966-1976 eleven climatic variables were recorded and used to develop a multiple linear regression model for predicting southern pine beetle outbreaks in East Texas. Four variables were significantly related; these were: 1) mean temperature for February of the current year, 2) total rainfall for the previous summer, 3) total rainfall for the previous fall, and 4) total rainfall for the previous spring. Of the yearly southern pine beetle infestation variation, 90.7% was accounted for by the regression analysis.

572. **KU T. T., SHELBURNE V. B., SWEENEY J. M.** 1979. Preventing damage from the southern pine beetle through better forest management. Univ. Arkansas at Monticello, Arkansas For. Comm., USDA, For. Serv. Southeast. Area, State and Priv. For., 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, SURVEY AND DETECTION, HAZARD/RISK RATING, LIGHTNING Southern pine beetle infestations were described for Arkansas. Lightning strikes and poor logging practices occurred in many of the infested stands. Natural conditions associated with beetle attack included high stand density, slow radial growth, young age, small diameter trees, and thin bark. Shortleaf pine was more susceptible to attack than loblolly pine. Recommendations for control included keeping basal area below 100 square feet per acre, reducing forest disturbances, and planting loblolly instead of shortleaf. Susceptibility to southern pine beetle can be predicted from total basal area, stand age, average radial growth in the last ten years, and hardwood basal area.

573. **KU T. T., SWEENEY J. M., SHELBURNE V. B.** 1976. Preliminary evaluation of site and stand characteristics associated with southern pine beetle infestations in Arkansas. Arkansas Farm Res. 25:2. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HAZARD/RISK RATING, STAND CONDITIONS In 17 southern Arkansas counties southern pine beetle-attacked trees/stands were found to have: 1) poor vigor, 2) higher stand densities, and 3) a higher incidence of stand disturbance. Preliminary results indicate: 1) beetle incidence was greater in stands of high density, 2) southern pine beetle-infested stands were younger than uninfested, 3) beetle-attacked plots had more pine stems/acre than control plots and 4) attacked plots were usually on drier sites with a higher sand content than control plots.

574. **KU T. T., SWEENEY J. M., SHELBURNE V. B.** 1977. Average site and stand conditions of the South Arkansas pine resource. Ark. Farm Res. 26:2. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS Pine stands are characterized in southern Arkansas. This will assist managers in characterizing southern pine beetle-infested stands.

575. **KU T. T., SWEENEY J. M., SHELBURNE V. B.** 1980. Site and stand conditions associated with southern pine beetle outbreaks in Arkansas--A hazard-rating system. South. J. Appl. For. 4:103-106. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, CONTROL-CULTURAL, SURVEY AND DETECTION, HAZARD/RISK RATING, LIGHTNING The southern pine beetle steadily spread through 24 southern Arkansas counties between 1969 and 1980. Analysis of 984 infested plots showed that stressed trees (small crowns, thin bark, and slow growth) were generally attacked while healthier trees escaped. In another study, 509 trees were studied and it was found that infestations occurred more commonly in plots with stressed trees. Disturbance (i.e., lightning, logging) increased stand susceptibility to southern pine beetle attack. Agents causing reduced radial growth predisposed stands to southern pine beetle attack; high stand density was the most significant factor. A workable hazard rating system is presented. Recommendations for silvicultural management are included.

576. **KU T. T., SWEENEY J. M., SHELBURNE V. B.** 1981a. Gulf Costal Plain, southern Arkansas. *In*, Site, stand and host characteristics of southern pine beetle infestations, J. E. Coster and J. L. Searcy, Eds. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. 1612. p. 16-22. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS Disturbances may predispose stands to attack but inherent stand conditions lead to larger and more devastating infestations. Basal area is the major factor leading to competition and a weakened stand condition that results in increased susceptibility to southern pine beetle attack.

577. **KU T. T., SWEENEY J. M., SHELBURNE V. B.** 1981b. Hazard rating of stands for southern pine beetle attack in Arkansas. *In*, Hazard-rating Systems in Forest Insect Pest Management: Symp. Proc., Athens, Georgia, 31 July - 1 August

1980, R. L. Hedden, S. J. Barras and J. E. Coster, Tech. Coords. USDA For. Serv. Gen. Tech. Rep. WO-27. p. 145-148. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS, LIGHTNING A southern pine beetle hazard-rating model for Arkansas used the variables total basal area per acre, hardwood basal area per acre, stand age, and radial growth in 10 years. Southen pine beetle attacks were also related to stand disturbances including lightning and logging activities.

578. **KUCERA D. R.** 1969. Marketing bark beetle infested southern pine trees. South. Lumberman, Dec. 1969. p. 101-102. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, CONTROL-CHEMICAL, CONTROL-CULTURAL, MISCELLANEOUS TECHNIQUES Timber management with regard to southern pine beetle suppression is reviewed. Silvicultural control techniques and the importance of prompt salvage operations are discussed.

579. **KUCERA D. R., BARRY P. J.** 1973. Southern pine beetle at epidemic proportions. For. Farmer 33(2):16-17,34. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CULTURAL, SURVEY AND DETECTION Since the loss of sawtimber in 1973 to the southern pine beetle could exceed 580 million board feet, prompt harvesting is a must. If some areas are inaccessible or the timber is unmerchantable, chemical controls may be used. Preventive measures include wide-spacing, using good seed stock, and thinning young, dense stands.

580. **KUCERA D. R., PIERCE D. A.** 1974 Current U. S. Forest Service efforts in cooperative southern pine beetle control. *In*, Southern Pine Beetle Symp., Payne T. L., Coulson R. N., Thatcher R. C., Eds. March 7-8, 1974, Tex. Agric. Exp. Stn., College Station, Tex. p. 52-53. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-LEGAL With the passage of the Forest Pest Control Act, the Secretary of Agriculture has the authority to provide both financial and technical assistance on Federal and non-Federal lands. State and Private Forestry, the action arm of the USDA Forest Service, is responsible for supplying research knowledge to Federal and non-Federal organizations. Southern pine beetle evaluations for project requests must be submitted during the spring. These evaluations are made to determine location and severity of the outbreak. Decisions for prevention are based on the economic and environmental impacts, benefit costs, and potential threats. Suppression is considered only as a last resort. Several southern pine beetle suppression methods are available for cost sharing: 1) salvage, 2) piling and burning, and 3) chemical treatment.

581. **KUDON L. H.** 1979. Studies on the host preferences of some Hymenopterous parasites of the southern pine beetle (*Dendroctonus frontalis*). Ph.D. Diss., Univ. Ga., Athens, Ga. 59 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis, Ips pini, Phloesinus dentatus. Heydenia unica, Roptrocerus xylophagorum, Coeloides pissodis, Dendrosoter sulcatus, Cecidostiba dendroctoni, Spathius pallidus, Spathius impus*). ATTRACTANTS, TRAPS AND CAGES, REARING, WATERSHED, MISCELLANEOUS TECHNIQUES, PARASITES Adults of Hymenopterous parasites which attack several species of bark beetles showed a strong preference for logs containing larvae of the same host species from which they were reared. An olfactometer is described that was used to test bark beetle parasite response to various host odors. Gas liquid chromatography was used to determine lipid composition of parasites. Lipid composition of parasites usually matched that of their host.

582. **KUDON L. H., BERISFORD C. W.** 1980. Influence of brood hosts on host preferences of bark beetle parasites. Nature 283:288-290. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips grandicollis, Ips calligraphus, Ips pini, Phloesinus dentatus*). PREDATOR, PARASITES, POPULATION DYNAMICS Several species of Hymenopterous parasites attack the southern pine beetle (*Dendroctonus frontalis*); the most common of these also parasitize other bark beetles. Since southern pine beetle tends to have a cyclic population, other beetles may be the key to maintaining reservoirs of parasites. Parasite-host preference comparing *D. frontalis, Ips grandicollis* and *Phloesinus dentatus* is reported. It was found that non-host specific parasites tend to prefer the hosts they were reared on but are able to use available hosts.

583. **KUDON L. H., BERISFORD C. W.** 1981a. An olfactometer for bark beetle parasites. J. Chem. Ecol. 7:359-366. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp., *Phloesinus dentatus. Heydenia unica*). ATTRACTANTS, PREDATOR, PARASITES, MISCELLANEOUS TECHNIQUES The design and utilization of an 'H'-type olfactometer to test the response of parasites of bark beetles to different beetle and host tree odors is discussed. Its advantages over the other types of olfactometers are described, and parasites which were tested showed strong positive responses to air drawn over beetle-infested logs and uninfested logs.

584. **KUDON L. H., BERISFORD C. W.** 1981b. Identification of host origin of parasites of bark beetles (Coleoptera: Scolytidae) by fatty acid composition. Can. Entomol. 113: 205-212. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). OVIPOSITION, PREDATOR, PARASITES, MORPHOLOGY AND PHYSIOLOGY The lipid composition patterns of the southern pine beetle, *Dendroctonus frontalis*, and other bark beetles were determined by gas-liquid chromatography. Peak heights and retention times are presented. The lipid patterns of parasites were compared to bark beetle hosts. Lipid composition of field collected parasites was compared to possible bark beetle hosts to determine origin. Coefficient of distance was used to compare host and parasite lipid patterns. Parasites ovipositing on a host were found to have lipid patterns similar to the host. Approximately 20% of the parasites that had attempted to parasitize *D. frontalis* had apparently developed on other hosts.

585. **KUSHMAUL R. J., CAIN M. D.** 1981. Gulf Costal Plain, southern Mississippi, Louisiana, and eastern Texas. *In*, Site, stand and host characteristics of southern pine beetle infestations, J. E. Coster and J. L. Searcy, Eds. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. 1612. p. 40-49. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS, LIGHTNING Characteristics of southern pine beetle-infested plots included flatter slopes, lower pH, higher pine and total basal area, heavier understory, higher stand density, higher site index, thicker bark, and slower radial growth. Infestations were often associated with recent logging activities and lightning strikes. Chemical brush control apparently has a long-term beneficial effect. A decline in vigor, possibly caused by excessive competition, often precedes beetle attack.

586. **KUSHMAUL R. J., CAIN M. D., ROWELL C. E., PORTERFIELD R. L.** 1979. Stand and site conditions related to southern pine beetle susceptibility. For. Sci. 25:656-664 . (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, HOST RESISTANCE, CONTROL-CULTURAL, HAZARD/RISK RATING A comparison of stand/site data was made between southern pine beetle-infested stands and the general forest area. Increased southern pine beetle activity usually occurs in stands with high basal area, high stand density, high proportion of pines, reduced radial growth, low soil pH, high site index, increased understory vegetation, and thicker bark of potential host trees. Discriminant models were derived from these data and a ranking system was constructed for southern pine beetle susceptibility.

587. **LANDGRAF A. E. JR.** 1966. Southern and Southeastern States. USDA For. Serv. For. Insect Conditions in the U. S. 1966. p. 31-32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle populations were at epidemic levels in many areas of the South and Southeast in 1966. Critical conditions existed in East Texas, Louisiana, Mississippi, and South Carolina. Beetle populations in Tennessee, and Alabama apparently collapsed because of low winter temperatures.

588. **LANE L. L.** 1976. Management information system for southern pine beetle research. Ph.D. Diss., Univ. Arkansas,

Fayetteville, Arkansas. 176 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, STATISTICAL METHODS The author describes a management information system which was designed to store, update, retrieve, and provide analysis of data collected during southern pine beetle research projects. Three basic programs are described: 1) creation of an indexed sequential data file, 2) addition of laboratory test data, and 3) access to file for summarization and statistical analysis. Examples of data forms, flow charts, programs, test outputs, etc. are included within the dissertation.

589. **LANIER G. N.** 1981. Cytotaxonomy of *Dendroctonus*. *In*, Application of Genetics and Cytology in Insect Systematics and Evolution, Proc. Symp., M. W. Stock, Ed., Natl. Meeting of the Entomol. Soc. Am. Atlanta, Dec. 1-2; 1980. For., Wildl. and Range Exp. Stn., Univ. of Idaho, Moscow. p. 33-66. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). GENETICS Lanier divides the genus *Dendroctonus* into six groups based on cytotaxonomy. *Dendroctonus frontalis* is placed in Group VI with *approximatus*, *brevicomis*, *mexicanus* and *vitei*. The synonomy of *D. arizonicus* with *D. frontalis* is corroborated.

590. **LARA R. R.** 1966. El combate directo de *Dendroctonus frontalis* Zimm. por derribo, descortezamiento y quema de la corteza de los arboles infestados. Bosques 3:8-11. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CHEMICAL, TAXONOMY, STAND CONDITIONS A layman's description of the biology and life cycle of the southern pine beetle in Mexico. Chemical control is recommended as a temporary emergency control. Silvicultural manipulation offers a less expensive long range control technique.

591. **LASHOMB J. H., NEBEKER T. E.** 1979. Investigations of egg niches, eggs, and rate of oviposition for *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 111:435-438. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). OVIPOSITION, POPULATION DYNAMICS The ratio of eggs to gallery length was found to be essentially the same and was less than 1.0 for all height strata of measured trees. An average of 36% more egg niches than eggs was evident in all strata. Egg deposition appears greater in the center of the bole than at its upper and lower extremes.

592. **LASSEN L. E.** 1975. What's ahead in research. For. Farmer 35(2):8-9,38-40. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW Reviews research efforts to control the southern pine beetle.

593. **LEE R. E.** 1954a. Much East Texas damage caused by forest insects in recent years. Tex. For. News 33(4):5-6 (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, REVIEW Reviews status of the southern pine beetle in East Texas for 1951-1954, and states that outbreaks should be reported to the Texas Forest Service.

594. **LEE R. E.** 1954b. Skidway inspections aid bark beetle research. J. For. 52:767,770. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Lee recommends examining log decks for evidence of *Dendroctonus frontalis*.

595. **LEUSCHNER W. A.** 1979a. Elements of a typical IPM system: The socio-economic and decisionmaking model. Proc. 1978 Soc. Am. For. Natl. Meet., St Louis., Mo. Oct., 1978. p. 263-267. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT The importance of economics in making management decisions is discussed in the context of an IPM model for southern pine beetle management.

596. **LEUSCHNER W. A.** 1979b. Impact analysis, interpretation and modeling. *In*, Current Topics in For. Entomol., XV. Int. Congr. Entomol., Waters W. E., Ed., Wash. D. C. Aug., 1976. p. 50-53. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT, MODELING, ECONOMICS Leuschner examines southern pine beetle impact in the context of forest resource management.

597. **LEUSCHNER W. A.** 1980. Chapter 7. Impacts of the southern pine beetle. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Tech. Bull. 1631. p. 137-151. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT Impacts of the southern pine beetle include timber, recreation, aesthetics, wildlife, water and grazing. A present net worth model is presented for timber. Recreational impacts are based on demand before and after attack. Aesthetic impact is based on loss to recreation primarily. Impact on water and wildlife is either zero or positive. Impact on timber and timber deterioration, and recreation is negative.

598. **LEUSCHNER W. A., BURKHART H. E., SPITTLE G. D., RAGENOVICH I. R., COULSON R. N.** 1976. A descriptive study of host and site variables associated with the occurrence of *Dendroctonus frontalis* Zimm. in East Texas. Southwest. Entomol. 1:141-149. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE, CONTROL-CULTURAL, ECONOMICS, IMPACT, STAND CONDITIONS Data were collected from 477 spots attacked by the southern pine beetle (*Dendroctonus frontalis*) on the Trinity District of the Davy Crockett National Forest. The parameters of height, DBH, basal area, soil drainage class, and spot size were measured and are presented. Some correlation with the above parameters and the habits of the southern pine beetle are suggested.

599. **LEUSCHNER W. A., MAINE J. D.** 1980. Estimating the southern pine beetle's grazing impact. Bull. Entomol. Soc. Am. 26:117-120. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). VERTEBRATES, ECONOMICS, MISCELLANEOUS TECHNIQUES, IMPACT *D. frontalis* increases the grazing capacity by opening up the forest canopy and increasing the amount of herbage. This study showed that this grazing impact may be ignored when making southern pine beetle management decisions.

600. **LEUSCHNER W. A., MATNEY T. G., BURKHART H. E.** 1977. Simulating southern pine beetle activity for pest management decisions. Can. J. For. Res. 7:138-144. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, MODELING FRONSIM, a simulation model developed to estimate the number of spots in a year, applies a frequency distribution to the number of trees per spot, and estimates the number of trees in each dbh class. Dollar values are applied to present net worth of a perpetual series of stands. A FRONSIM estimate for damages incurred in 1974 is compared to an estimate of the Texas Forest Service.

601. **LEUSCHNER W. A., MAX T. A., SPITTLE G. D., WISDOM H. W.** 1978. Estimating southern pine beetle timber damages. Bull. Entomol. Soc. Am. 24:29-34. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, STATISTICAL METHODS, MODELING Leuschner examines traditional methods of appraising timber damage and suggests a new method of present net worth employing a 0.10 discount rate. Utilizing this method to determine damage of *Dendroctonus frontalis* on the Trinity District of the Davy Crockett National Forest, damage from July 1974 through June 1975 was estimated to be $5,764 for the 479 spots measured.

602. **LEUSCHNER W. A., NEWTON C. M., NEAL R. B.** 1974. Impact of the southern pine beetle in East Texas--1971 and 1972. *In*, Southern Pine Beetle Symp., Payne T. L., Coulson R. N., Thatcher R. C., Eds., March 1-8, 1974. Tex. Agric. Exp. Stn., College Station, Tex. p. 22-25. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT Costs and budget appropriations are given for survey and detection and research expenses related to the southern pine beetle in East Texas for the years 1971 through 1972. Sources of funding are presented.

603. **LEUSCHNER W. A., SHORE D. G., SMITH D. W.** 1979. Estimating the southern pine beetle's hydrologic impact. Bull. Entomol. Soc. Am. 25:147-150. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT Estimates of nine different forested sites, within the southern United States, indicate that water yield changes, caused by *Dendroctonus frontalis*, are generally considered to be insignificant. Affects on water quality, in terms of sediment,

nutrient content, and water temperature, are considered to be insignificant. Economic impact on water yield is discussed and it was concluded that water has no market price in the economic sense. However, special cases may exist where an infestation may result in an economic loss in water yield or quality.

604. **LEUSCHNER W. A., THATCHER R. C., PAYNE T. L., BUFFAM P. E.** 1977. SPBRAP-An integrated research and applications program. J. For. 75:478-480. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, MISCELLANEOUS TECHNIQUES, INTEGRATED PEST MANAGEMENT Leuschner discusses the problem of the southern pine beetle in light of its destruction to timber in the South. In response to the problem, the USDA has initiated the Southern Pine Beetle Research and Applications Program. The administrative coordination of the program is briefly discussed. An outline of the three phases of the program is presented.

605. **LEUSCHNER W. A., YOUNG R. L.** 1978. Estimating the southern pine beetle's impact on reservoir campsites. For. Sci. 24:527-537. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, AESTHETICS Demand functions were estimated using the Hotelling-Clawson-Knetsch (HCK) method and a gravity potential model and applied to selected recreation sites on the Sam Rayburn and B. A. Steinhagen Reservoirs in 1973. The independent variable, percent of pine crown, was varied in order to simulate the effects of the southern pine beetle. Dollar values of damages are presented.

606. **LEVI M.** 1978. Blue-flecked pine panelling: A new market for southern pine beetle-killed trees? South. Lumberman 237(2944):70-71. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION Levi explores the possibility of utilizing southern pine beetle-killed wood as decorative panelling. The effects of the stain fungi are discussed. Two limitations on utilization are presented.

607. **LEVI M. P.** 1981. A guide for using beetle-killed southern pine based on tree appearance. USDA Comb. For. Pest and Dev. Prog. Agric. Handb. No. 572. 19 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Levi discusses the use of southern pine beetle-killed timber. Included are appearances of Class A (some needles present, twigs still attached) and Class B (twigs missing, decay and insect-damaged wood apparent) pines. Utilization guidelines for beetle-killed trees are included for lumber, posts, plywood, hardboard, pulp and fuelwood. Properties of wood products are listed. Included is a photograph of a den decorated with southern pine beetle-killed timber.

608. **LEVI M. P.** 1982. Utilization of beetle-killed southern pine based on tree appearance. Southern pine beetle fact sheet number 25. USDA For. Serv. For. Pest Manage. For. Bull. SA-FB/P 44. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Pines killed by southern pine beetle can be used if processed soon after attack.

609. **LEVI M. P., DIETRICH R. L.** 1976. Utilization of southern pine beetle-killed timber; a survey of attitudes and available information. For. Prod. J. 26(4):42-48. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, REVIEW, WOOD UTILIZATION In North Carolina, 632 buyers of pine were sent questionnaires regarding their purchase and utilization of southern yellow pine beetle-killed trees. Of those responding, almost 50% of pole, piling, and post buyers stated that they would not purchase beetle-killed trees. Only 5% of the pulpwood buyers refused to accept such trees. Ten to 22% of the manufacturers of lumber and dimension stock refused to accept dead trees. Most respondents stated that they paid a reduced price for beetle-killed wood. However, two-thirds of the pulpwood buyers did not. In general, the survey indicates that insect-attacked yellow pine can be economically utilized. The authors suggest a need for greater knowledge pertaining to the rate of deterioration and its affect on utilization.

610. **LEWIS K. R.** 1971. The terpenes of Virginia pine (*Pinus virginiana* Mill.) with investigation of their attractancy to the southern pine beetle. Ph. D. Diss., Va. Polytech. Instit. and State Univ., Blacksburg, Va. 85 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION Terpenes of Virginia pine are attractive to the southern pine beetle.

611. **LEWIS K. R.** 1973. Tree killers...pine bark beetles. Tex. Agric. Ext. Serv. Fact Sheet No. L-921. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). LIFE HISTORY-GENERAL, CONTROL-CHEMICAL Life history and habits of the bark beetle complex of southern pines are reviewed. Signs of attack, prevention of infestations, and chemical controls are outlined.

612. **LEWIS K. R., PAYNE T. L., COULSON R. N.** 1973. Forest entomology in Texas. Tex. Agric. Exp. Stn., Tex. Agric. Prog. 19:16-19. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW The authors review the problem of the southern pine beetle in Texas forests, briefly discuss methods of control, and evaluate the status of current research programs of the Texas Agriculture Experiment Station at Texas A&M University with particular mention to the work with pheromones. A brief proposal for a sound entomology program is given.

613. **LINDQUIST E. E.** 1969. Mites and the regulation of bark beetle populations. Proc. Second Int. Congr. Acarology, 1967. p. 389-399. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp., *Ips* spp., *Tomicus* spp., *Scolytus* spp. ACARINA). PREDATOR, PARASITES, HOST SELECTION, COMMENSALISM AND SYMBIOSIS, MITES Lindquist briefly reviews past published works of mites associated with scolytids from 1923 to the present. He also discusses current progress coordinated by J. C. Moser on *Dendroctonus frontalis* Zimm., and suggests a course of future research.

614. **LINDQUIST E. E., HUNTER P. E.** 1965. Some mites of the Genus *Proctolaelaps* Berlese (Acarina: Blattisociidae) associated with forest insect pests. Can. Entomol. 97:15-32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*). TAXONOMY, MITES *Proctolaelaps dendroctoni*, a new species of mite, was collected and described from galleries of *Dendroctonus frontalis*.

615. **LINIT M. J.** 1981. The natural enemy component of within-tree southern pine beetle mortality. Ph.D. Diss., Univ. Arkansas, Fayetteville, Ark. 45 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Scolopscelis mississippensis, Medetera bistriata, Roptrocerus xylophagorum, Coeloides pissodis, Heydenia unica, Dendrosoter sulcatus*). PARASITES, PREDATOR, COMPETITION Southern pine beetle parasites and predators were mechanically excluded from the bark of infested pine trees in order to investigate natural enemy component mortality. Mean baseline beetle mortality was 69.48% Mortality when predators and parasites were not excluded was 94.40%. The parasite-predator complex caused 24.92% of the within-tree mortality. Predator density exceeded parasite density for all treatments.

616. **LINIT M. J., STEPHEN F. M.** 1978. Comparison of methods for estimation of attacking adult populations of *Dendroctonus frontalis*. J. Econ. Entomol. 71:732-735. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). RADIOGRAPHY, MISCELLANEOUS TECHNIQUES, POPULATION DYNAMICS Three methods of estimating the parameter of attacking bark beetle populations were examined from disc samples taken from the mid-bole of attacked loblolly pines (*Pinus taeda*). Results indicate that the three methods of X-ray analysis, dissection for attacking adults, and determination of attack site (multiplication by two was necessary to account for the presence of both male and female of species) were found to be equally reliable estimators.

617. **LINIT M. J., STEPHEN F. M.** 1982. Observations on trees resisting southern pine beetle attack. J. Ga. Entomol. Soc. 17:351-356. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST RESISTANCE Mean attack density for resistant trees was 13.5 and 9.8 attacks per square meter for two loblolly pines successfully attacked. A resistant tree had a mean attack density of 419 per square meter.

618. **LINTNER J. A.** 1894. The insect that kills the pine tree borers. Gardening 2:292. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus formicarius*). PREDATOR Discusses a clerid, *Cleris formicarius*, as a predator of the southern pine beetle.

619. **LOOK M.** 1976. Improved synthesis of *endo*-brevicomin for the control of bark beetles (Coleoptera: Scolytidae). J. Chem. Ecol. 2:83-86. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus brevicomis*). ATTRACTANTS, CONTROL-CHEMICAL A new method for synthesizing the compound *endo*-brevicomin is presented. No *exo*-isomer is present in this compound.

620. **LORIO P. L. JR.** 1966. *Phytophthora cinnamomi* and *Pythium* species associated with loblolly pine decline in Louisiana. Plant Dis. Rep. 50(8):596-597. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Phytophthora cinnamomi, Phythium* sp.). PATHOGENS, HOST SELECTION, HOST RESISTANCE, STAND CONDITIONS Declining trees probably serve as bark beetle brood trees.

621. **LORIO P. L. JR.** 1968. Soil and stand conditions related to southern pine beetle activity in Hardin County, Texas. J. Econ. Entomol. 61:565-566. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, HOST SELECTION, HOST RESISTANCE, STAND CONDITIONS Texas Forest Service surveys of southern pine beetle activity between 1958 and 1963 were correlated with soil and stand variables at the site of infestation initiation. Variables included were elevation, percent slope, aspect, soil-drainage class, texture, structure, consistency, tree basal area, age, radial growth (last ten years), height, DBH, and site index. The general association of site-stand factors to infestation occurrence is discussed, but no rigorous analysis is provided.

622. **LORIO P. L. JR.** 1973. Declining pines associated with bark beetle activity in Allen Parish, La. USDA For. Serv. Res. Note SO-163. 3 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). HOST SELECTION, HOST RESISTANCE, POPULATION DYNAMICS From June 1969 through November 1971, southern pine beetle activity was found on five of 100 0.1-acre plots that had declining trees. This study lends credence to the idea that declining pines are important in the maintenance of southern pine beetle populations during endemic periods.

623. **LORIO P. L. JR.** 1978. Developing stand risk classes for the southern pine beetle. USDA For. Serv. Res. Pap. SO-144. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, CONTROL-CULTURAL, STAND CONDITIONS, IMPACT, HAZARD/RISK RATING The results of studies in the Gulf Coastal Plain indicate that southern pine beetle (*Dendroctonus frontalis* Zimm.) infestations tend to occur in stands that are in or near culmination of the mean annual increment. Lorio indicates that easily accessible data such as forest type, tree size and age, basal area, and site index can be used to develop a southern pine beetle risk classification system.

624. **LORIO P. L. JR.** 1980a. Chapter 8. Rating stands for susceptibility to SPB. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel. Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Tech. Bull. 1631. p. 153-163. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, HAZARD/RISK RATING Stands susceptible to the southern pine beetle were hazard rated using discriminant function analysis and qualitative risk rating systems. In the Coastal Plain, landform, basal area pine/acre, and tree height ranked stands for hazard to southern pine beetle. A CISC system using USDA Forest Service data was developed in Louisiana. In the Georgia Piedmont, a system based on stand, tree and soils was developed. Aerial photos were used to develop hazard rating systems in Texas. Basic needs include further site/stand investigations to understand host and southern pine beetle dynamics.

625. **LORIO P. L. JR.** 1980b. Loblolly pine stocking levels affect potential for southern pine beetle infestation. South. J. Appl. For. 4:162-165. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, MODELING, HAZARD/RISK RATING, STAND CONDITIONS When untended loblolly stands were stocked more than 80% of normal, individual trees became more susceptible to southern pine beetle attack. Basal area growth declined, oleoresin reservoirs were reduced, and severe moisture deficits were more commonly observed. The guides and recommendations are presented to reduce susceptibility to southern pine beetle attacks and damage.

626. **LORIO P. L. JR., BENNETT W. H.** 1974. Recurring southern pine beetle infestations near Oakdale, Louisiana. USDA For. Serv. Res. Pap. SO-95. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*). HOST SELECTION, HAZARD/RISK RATING, LIGHTNING This study, conducted on 31,500 acres near Oakdale, Louisiana, revealed the relationship between southern pine beetle (*Dendroctonus frontalis* Zimm.) attacks and stand density, proportion of pine sawtimber, nearness to an earlier infestation, and lightning strikes incidence.

627. **LORIO P. L. JR., HODGES J. D.** 1968a. Microsite effects on oleoresin exudation pressure of large loblolly pines. Ecology 49:1207-1210. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE Changes in OEP affect host resistance to bark beetles.

628. **LORIO P. L. JR., HODGES J. D.** 1968b. Oleoresin exudation pressure and relative water content of inner bark as indicators of moisture stress in loblolly pines. For. Sci. 14:392-398. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE This study measured the effects of artificially induced moisture stress on the oleoresin exudation pressure (OEP) and relative water content (RWC) of the inner bark of loblolly pine in a well-stocked, 40 year old stand in Allen Parish, Louisiana. Single early morning measurements of OEP did not reflect soil moisture stress. RWC reflected changes in soil moisture and diameter growth. Trees that were continuously flooded showed the most dramatic reduction in OEP and RWC, and were attacked and killed by bark beetles in the spring and summer of 1967.

629. **LORIO P. L. JR., HODGES J. D.** 1971. Microrelief, soil water regime, and loblolly pine growth on a wet, mounded site. Soil Sci. Soc. Am. Proc. 35(5):795-800. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. PINACEAE). HOST SELECTION, STAND CONDITIONS Microrelief and soil characteristics in a 40-year old loblolly pine (*Pinus taeda*) stand on a mounded area in Allen Parish, Louisiana, were related to diameter and height growth responses. Water retention and depletion were also compared on the two sites. Results indicate greater growth rates on flats. However, the soil water regime on flats indicates instability that affects tree rooting and may eventually affect susceptibility to bark beetle attack.

630. **LORIO P. L. JR., HODGES J. D.** 1974. Host and site factors in southern pine beetle infestations. *In*, Southern Pine Beetle Symp., Payne T. L., Coulson R. N., Thatcher R. C., Eds., March 7-8, 1974. Agric. Exp. Stn., College Station, Tex. p. 32-34. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*). HOST SELECTION, HOST RESISTANCE, WEATHER RELATIONSHIPS, HAZARD/RISK RATING A review in the work of host response to stress, soil, and site and stand conditions that may contribute to infestations of the southern pine beetle (*Dendroctonus frontalis* Zimm.), suggests that current knowledge may be used to develop southern pine beetle risk rating systems.

631. **LORIO P. L. JR., HODGES J. D.** 1977. Tree water status affects induced southern pine beetle attack and brood production. USDA For. Serv. Pap. SO-135. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*.). HOST RESISTANCE, POPULATION DYNAMICS A study conducted from 1973 to 1975 in the West Gulf Coastal Plain, examined susceptibility to attack of loblolly pine (*Pinus taeda*) by the southern pine beetle as trees were put under artificially induced moisture stress conditions. Initial attack and brood development were studied. Results indicate a shifted

physiological status that offered minimal resistance to initial attack or brood development.

632. **LORIO P. L. JR., HOWE V. K., MARTIN C. N.** 1972. Loblolly pine rooting varies with microrelief on wet sites. Ecology 53:1134-1140. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST RESISTANCE, MORPHOLOGY AND PHYSIOLOGY, STAND CONDITIONS Deficiencies in tree rooting, associated with excess water, probably contribute to premature tree decline and susceptibility to bark beetle attack.

633. **LORIO P. L. JR., MASON G. N., AUTRY G. L.** 1982. Stand risk rating for the southern pine beetle: Integrating pest management with forest management. J. For. 80:212-214. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS Two methods for hazard-rating stands for southern pine beetle are presented. The authors stress the idea of using resource inventory data for making forest management decisions.

634. **LORIO P. L. JR., SOMMERS R. A.** 1981a. Gulf Costal Plain, central Louisiana. *In*; Site, stand and host characteristics of southern pine beetle infestations, J. E. Coster and J. L. Searcy, Eds. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. 1612. p. 23-39. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS Forest type, stand condition class, site index and age of stands reported on Continuous Inventory of Stand Conditions (CISC) data on USDA Forest Service lands in Louisiana showed consistent associations with southern pine beetle infestations. Loblolly pine type, immature and mature sawtimber, on sites with an index of 80 or higher and older than 35 years comprised the great majority of infestations.

635. **LORIO P. L. JR., SOMMERS R. A.** 1981b. Use of available resource data to rate stands for southern pine beetle risk. *In*, Hazard-rating Systems in Forest Insect Pest Management: Symp. Proc., Athens, Ga. 31 July - 1 August 1980, R. L. Hedden, S. J. Barras and J. E. Coster, Eds. USDA Tech. Rep. WO-27. p. 75-78. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING A risk-rating system based on CISC (Continuous Inventory of Stand Conditions) data is used to hazard rate USDA For. Serv. lands in Louisiana. The system uses the variables forest type, stand condition, method of cut, operability, and site index to rate stands as low, medium, or high risk to the southern pine beetle.

636. **LORIO P. L., YANDLE D. O.** 1978. Distribution of lightning-induced southern pine beetle infestations. South. Lumberman, Jan., p. 12-13. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS, HOST SELECTION, WEATHER RELATIONSHIPS, LIGHTNING Lightning-induced infestations occurred most frequently in mid- to late summer. Southern pine beetle infestations related to lightning strikes may be related to stand conditions and local beetle populations.

637. **LYON R. L.** 1958. A useful secondary sex character in *Dendroctonus* bark beetles. Can. Entomol. 90:582-584. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). SEX-RATIOS, TAXONOMY The seventh abdominal tergite was used to separate the sexes.

638. **MACANDREWS A. H.** 1926. The biology of the southern pine beetle. M. S. Thesis, New York State Coll. of For., Syracuse, New York. 121 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, COMPETITION, PREDATOR, PARASITES, ECOLOGICAL DISTRIBUTION, SEASONAL OCCURRENCE, AGGREGATION, DISTRIBUTION, HOST SELECTION, HOST RESISTANCE, REARING, REVIEW, MISCELLANEOUS TECHNIQUES This paper represents some of the original work done on southern pine beetle biology. The general life history of the insect is discussed, as well as observations of host-tree resistance and moisture-temperature relationships.

639. **MACGOWN M. W., NEBEKER T. E.** 1977. Observations on *Cryturgus aleutaceus* Schwartz (Coleoptera: Scolytidae), an associate of the southern pine beetle. Entomol. News 88:61-66. (COLEOPTERA: SCOLYTIDAE; *Crypturgus aleutaceus*; *Dendroctonus frontalis*). COMPETITION, ECOLOGICAL DISTRIBUTION, MORPHOLOGY AND PHYSIOLOGY *Crypturgus aleutaceus* was recorded for the first time as an associate of the southern pine beetle in Mississippi. SEM photographs pointed out antennal morphology.

640. **MACGUIDWIN A. E.** 1979. Biology of *Contortylenchus brevicomi* (Nematoda: Sphaerulariidae) and its effect on gallery construction and fertility of *Dendroctonus frontalis* (Coleoptera: Scolytidae). M. S. Thesis, Univ. Fla., Gainesville, Fla. 59 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Contortylenchus brevicomi, Unikaryon minutum*). EGG, ADULT, OVIPOSITION, REARING, PARASITES Southern pine beetles were field collected and introduced into loblolly pine bolts. Beetles were then collected at one, two, and three week maturation. These were examined for internal parasites, particularly *Contortylenchus brevicomi* (Nematoda: Sphaerulariidae). This parasite was found in 25% of all beetles. It was found that *C. brevicomi* affects beetle 'vigor', reducing gallery construction, female egg niche construction, and the number of eggs per unit of gallery. Data on progeny survival is given. Life table construction is discussed.

641. **MACGUIDWIN A. E., SMART G. C. JR., WILKINSON R. C., ALLEN G. E.** 1980. Effect of the nematode *Contortylenchus brevicomi* on gallery construction and fecundity of the southern pine beetle. J. Nematologica. 12:278-282. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-BIOLOGICAL, PARASITES, NEMATODES The nematode reduced southern pine beetle fecundity and gallery construction.

642. **MACGUIDWIN A. E., SMART G. C., ALLEN G. E.** 1980. Redescription and life history of *Contortylenchus brevicomi*, a parasite of the southern pine beetle, *Dendroctonus frontalis*. J. Nematologica. 12:207-212. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-BIOLOGICAL, PARASITES, NEMATODES The nematode infested the southern pine beetle and reduced populations.

643. **MAGNUS P., ROY G.** 1978. A short synthesis of (f)-(+)-frontalin and latia luciferin using new organosilicon reagents. Chem. Soc. Chem. CONNUN 7:297-298. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS The synthesis of (f)-(+)-frontalin is presented.

644. **MAINE J. D.** 1979. A qualitative analysis of the southern pine beetle's (*Dendroctonus frontalis* Zimm.) impact on wildlife, wildfire, and grazing. M. S. Thesis, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 133 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). VERTEBRATES, FIRE, MODELING, IMPACT, FIRE A qualitative model indicated that the southern pine beetle had a positive impact on woodpeckers, quail, rabbits, deer, small mammals, and other birds. No negative impacts were found for any wildlife group. Fire intensity and rate of spread are increased in southern pine beetle spots; however, since spots are small and dispersed, total impact on fire is small. Grazing impacts were too small to be considered in southern pine beetle control decisions.

645. **MAINE J. D., LEUSCHNER W. A.** 1978. The economic impact of the southern pine beetle on wildlife habitat and populations. Va. J. Sci. 29:42. (Abst.) (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT Southern pine beetle had a positive impact on wildlife.

646. **MAINE J. D., LEUSCHNER W. A., TIPTON A. R.** 1980. A qualitative analysis of the southern pine beetle's wildlife impact. Va. Polytech. Inst. & State Univ. School For. Wildl. Resour., Publ. No. FWS-1-80. 48 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). VERTEBRATES, WATERSHED, IMPACT Change in forage production was estimated at 366 pounds per acre of southern pine beetle spot. Southern pine beetle was estimated to increase the linear edge by 2,000 feet per acre of southern pine beetle spot. Spots also provided snags for nesting birds. Southern pine beetle had a positive effect on woodpeckers, quail, rabbits, deer, small mammals, and other birds. Increases in edge and food were most of the positive impacts; however, these impacts are small. More than 25 acres of southern pine beetle spots are needed to increase the

carrying capacity of one deer.

647. **MAKI T. E., HAZEL D. W., HALL J. R.** 1981. Piedmont-North Carolina. *In*, Site, stand and host characteristics of southern pine beetle infestations. J. E. Coster and J. L. Searcy, Eds. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. 1612. p. 74-81. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Phytophthora cinnamomi*). HAZARD/RISK RATING, STAND CONDITIONS In the Piedmont, shortleaf pines are more prone to attack by southern pine beetle. This may be due to the association with littleleaf disease (*Phytophthora cinnamomi*).

648. **MARCHANT K. R., BORDEN J. H.** 1976. Worldwide introduction and establishment of bark and timber beetles (Coleoptera: Scolytidae and Platypodipae). Pestology Manage. Pap. No. 6, Pestology Centre Dep. Biol. Sci., Simon Fraser Univ., Burnaby B. C. Can. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Rates *Dendroctonus frontalis* as an aggressive bark beetle, but not established on new hosts.

649. **MARLATT C. L.** 1930. Report of the Chief of the Bureau of Entomology. USDA Bur. Entomol. p. 47-48. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Excess moisture (rainfall) in April and May resulted in decreased southern pine beetle populations.

650. **MARLATT C. L.** 1931. Report of the Chief of the Bureau of Entomology. USDA Bur. Entomol. p. 59. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Southern pine beetles were correlated with deficiency in precipitation.

651. **MARLATT C. L.** 1933. Report of the Chief of the Bureau of Entomology, 1933. USDA Bur. Entomol. p. 29. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION A destructive southern pine beetle outbreak destroyed 7,500,000 board feet of timber in the Southeast.

652. **MARLER J. E., BARRAS S. J.** 1978. A simple method for the production of microbe-free southern pine beetles. J. Ga. Entomol. Soc. 13:121-124. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MISCELLANEOUS TECHNIQUES, COMMENSALISM AND SYMBIOSIS, REARING Microbe-free southern pine beetles were produced by first surface sterilizing field collected pupae using a modified White's Solution. Adults emerging from these pupae were fed an artificial diet containing these antimicrobial compounds: sorbic acid, gentimycin sulfate, and clotrimazole. Microbe-free beetles were produced within five days and lived up to two weeks.

653. **MASK R. A.** 1982. Bark beetle risk and hazard rating for outdoor recreation areas in East Texas. M. S. For. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 59 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips calligraphus*). RECREATION, HAZARD/RISK RATING, STAND CONDITIONS A classification system was developed for pines attacked by *Ips* and BTB in recreation areas in East Texas. A southern pine beetle hazard rating system indicated low or moderate hazard in the recreation areas.

654. **MASON A. B.** 1911. Southern logging superintendents. South. Lumberman 64(836):35. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Briefly describes meeting of logging superintendents discussing southern pine beetle and other problems.

655. **MASON A. B.** 1912. The southern pine beetle and its control. N. C. Geol. and Econ. Survey Press Bull. 60. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL Brief summary of the southern pine beetle.

656. **MASON G. N.** 1979. Small scale aerial photo stand susceptibility rating for southern pine beetle in East Texas. *In*, Proc. of the Seventh Biennial Workshop on Color Aerial Photography in the Plant Sci. Univ. Cal. Davis, May 15-17, 1979. p. 125-135. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, MODELING, HAZARD/RISK RATING By using existing resource photography, effective hazard rating and implementation may be best approached through aerial photographic stand classification. Five of the ten most definitive variables significant in ground investigations (BA/A, species, DBH, height and landform) could be assessed with good accuracy by utilizing traditional forest photo interpretation procedures. A system is presented which uses small scale aerial photos for habitat type classification, hazard assignment, and verification of research models.

657. **MASON G. N.** 1980. Texas southern pine beetle hazard rating guide. Stephen F. Austin State Univ., School of For., Nacogdoches, Tex. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, HOST SELECTION, MISCELLANEOUS TECHNIQUES, HAZARD/RISK RATING A hazard rating guide for southern pine beetle using basal area pine, landform and tree height is incorporated onto a circular chart. The guide is based on data from over 1100 southern pine beetle-infested and non-infested plots in East Texas.

658. **MASON G. N., HICKS R. R. JR., BRYANT C. M. V., MATHEWS M. L., KULHAVY D. L., HOWARD J. E.** 1981. Rating southern pine beetle hazard by aerial photography. *In*, Hazard-rating systems in forest insect pest management: Symp. Proc., Athens, Georgia, 31 July - August 1980, R. L. Hedden, S. J. Barras and J. E. Coster, Tech. Coords. USDA For. Serv. Gen. Tech. Rep. WO-27. p. 109-114. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING Model development and verification for hazard rating for southern pine beetle are presented. The variables used included basal area (pine) per acre, dominant or codominant tree height and landform. Southern pine beetle spots were restricted to very high hazard types during endemic years, but not in epidemic years.

659. **MASON G. N., HOWARD J. E.** 1980. A test of small-scale aerial photo susceptibility ratings for southern pine beetle in East Texas. Workshop on practical applications of remote sensing to timber inventory, Edmonton, Alberta, Canada. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING Discriminant function analysis of 898 samples in infested and uninfested host stands for southern pine beetle resulted in a predictive model for susceptibility to southern pine beetle attack.

660. **MASON G. N., JONES J. L. III.** 1969. Forest pest activity in Texas - 1969. Tex. For. Serv. Circ. No. 201. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, ECONOMICS, IMPACT, CONTROL-CULTURAL, CONTROL-CHEMICAL The southern pine beetle killed 1.7 million cubic feet of merchantable pine timber in 1969 in East Texas. The epidemic covered about 6.3 million acres. Southern pine beetle was controlled with either salvage or cut-and-leave. Results with cacodylic acid resulted in 97% brood reduction.

661. **MASSEY C. L.** 1957. Four new species of *Aphelenchulus* (Nematoda) parasitic in bark beetles in the United States. Helminthol. Soc. Wash. Proc. 24:29-34. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PARASITES, NEMATODES High mortality of southern pine beetle occurs from nematodes in certain cases.

662. **MASSEY C. L.** 1974. Biology and taxonomy of nematode parasites and associates of bark beetles in the United States. USDA Agric. Handb. No. 446. 233 p. (NEOTYLENCHOIDEA; *Contortylenchus reversus*. COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). LARVAE, PREDATOR, PARASITES, TAXONOMY, NEMATODES The biology and taxonomy of 32 nematode parasites and 114 nematode associates of 45 species of bark beetles are presented.

663. **MATHEWS M. L.** 1978. Forest stand mapping from LANDSAT and aircraft imagery to assess southern pine beetle susceptibility. M. S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 56 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, HAZARD/RISK RATING, STAND CONDITIONS A multi-

stage sampling method was used to identify site, stand and tree variables associated with southern pine beetle infestations. Level I used 1:250,000 LANDSAT imagery; Level II used high altitude 1:60,000 NASA photography supplemented with 35mm low altitude photography. Variables associated with southern pine beetle infestations included pine stocking, basal area, crown closure, DBH, and height.

664. **MATTOON W. R.** 1915a. Life-history of shortleaf pine. USDA Bull. No. 244. p. 35. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, REVIEW The southern pine beetle is the most important insect pest of shortleaf pine. Serious outbreaks of the insect occurred in 1890, 1893, and 1910.

665. **MATTOON W. R.** 1915b. Shortleaf pine: Its economic importance and forest management. USDA Bull. No. 308. p. 25-26. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL, REVIEW The southern pine beetle is an important enemy of shortleaf pine. This article details the evidences of infestation by southern pine beetle and outlines various methods of control.

666. **MATTOON W. R.** 1926. Longleaf pine primer. USDA Farmers' Bull. No. 1486. p. 21. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, SURVEY AND DETECTION Briefly describes southern pine beetle.

667. **MATTOON W. R.** 1954. Shortleaf pine. USDA Farmers' Bull. No. 1671. p. 42-43. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CERAMBYCIDAE; *Monochamus* sp.). IMPACT Damage by the southern pine beetle is briefly described.

668. **MAWBY W. D.** 1980. Development of an upper echelon submodel for the southern pine beetle hierarchy. Ph. D. Diss., N. C. State Univ., Raleigh, N. C. 170 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING A four level hierarchial model which specifies variables and dynamics for three level to level transition submodels was constructed. The key concepts of tree, neighborhood, patch, and region are specified. Nonparametric, multivariate, and time-space series methods of statistics are surveyed. The uses of the model in forest management surveillance and control are discussed.

669. **MAYYASI A. M., COULSON R. N., FOLTZ J. L., HAIN F. P., MARTIN W. C.** 1976. Functional description of within-tree larval and progeny adult populations of *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 108:363-372. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LARVAE, ADULT, DISTRIBUTION, STATISTICAL METHODS, POPULATION DYNAMICS The larval distribution of southern pine beetles within sample units (100 cm. bark disks) and the distribution of larvae and progeny adults along the infested bole were examined for 50 trees. Larvae were uniformly distributed within disks, and a nonlinear model was successfully fitted to the distribution of larvae and progeny adults on the normalized infested bole height. Larval distribution peaked just below mid-bole, while adult distribution peaked just above mid-bole.

670. **MAYYASI A. M., COULSON R. N., FOLTZ J. L., HARVEY A. E.** 1975. A quality control approach to the evaluation of survey sampling procedures for the southern pine beetle. J. Econ. Entomol. 68:336-338. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, STATISTICAL METHODS Operating characteristics curves based on aerial estimation of the size of southern pine beetle infestations as compared to ground inventories of the same infestations indicate unacceptably large errors. An average error of 149% (actual infestation size 2.49 x the aerial estimate) was found.

671. **MAYYASI A. M., PULLEY P. E., COULSON R. N., DEMICHELE D. W., FOLTZ J. L.** 1976. Mathematical description of within-tree distributions of the various developmental stages of *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae). Res. Popul. Ecol. 18:135-145. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, STATISTICAL METHODS Probability density functions for the various within-tree developmental life stages of *Dendroctonus frontalis* are derived. Differences between some distributions are discussed. The possibility of the existence of a negative feed-back mechanism which enables the beetle to make optimum utilization of the available resources is proposed. The concept of an optimum location on the infested bole (where maximum survivorship occurs) is advanced.

672. **MCCAMBRIDGE W. F., KOWAL R. J.** 1957. Forest insect conditions in the Southeast during 1956. USDA For. Serv. Southeast. For. Exp. Stn. Stn. Pap. No. 76, Asheville, N. C. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION, IMPACT The southern pine beetle killed an estimated six million board-feet of pine during 1956. Over 2.75 million board-feet were salvaged. Impact was greatest in the Southern Appalachian regions of western North Carolina, and South Carolina. The main control program was cutting and spraying with BHC.

673. **MCCAMBRIDGE W. F., NAGEL W. P., KOWAL R. J.** 1958. Forest insect conditions in the Southeast during 1957. USDA For. Serv. Southeast. For. Exp. Stn. Stn. Pap. No. 93, Asheville, N. C. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp. CLERIDAE; *Thanasimus dubius*). CONTROL-CHEMICAL, SURVEY AND DETECTION, WEATHER RELATIONSHIPS, IMPACT Southern pine beetle epidemics were confined mainly to the Southern Appalachians in western North Carolina, eastern Tennessee, northeastern Georgia, and northwestern South Carolina. About 95,000 trees (2.33 million board-feet of pine) were killed. Direct control included felling and spraying with BHC or burning. Cold December weather may have killed much of the southern pine beetle population. *Thanasimus dubius* larvae survived better than southern pine beetle during the winter. Infestations are estimated by state.

674. **MCCAMBRIDGE W. F., ROSSELL H.** 1957. Recommended procedures for control of the southern pine beetle. USDA For. Serv. Southeast. For. Exp. Stn., Asheville, N. C. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, CONTROL-CHEMICAL Procedures for controlling the southern pine beetle on forest service lands are summarized.

675. **MCCARTY F. A., BILLINGS P. M., RICHERSON J. V., PAYNE T. L., EDSON L. J.** 1980. Response of the southern pine beetle to behavioral chemicals in the laboratory. J. Ga. Entomol. Soc. 15:307-317. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS Both sexes of *Dendroctonus frontalis* responded to frontalin, *alpha*-pinene, and frontalure. Male response was significantly greater to both frontalin and frontalure. Males were attracted to verbenone, females were not. At higher verbenone concentrations, the response of both sexes to attractants was inhibited.

676. **MCCLELLAND W. T., HAIN F. P.** 1979. Survival of declining *Dendroctonus frontalis* populations during a severe and nonsevere winter. Environ. Entomol. 8:231-235. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS, WEATHER RELATIONSHIPS A comparison of brood survival in declining southern pine beetle infestations between severe and mild winters in North Carolina showed an extreme difference in survival, but no net effect on population trends. Infestations did not survive or proliferate following either mild or severe winters. Emergence and subsequent dispersal mortality on warm days were believed to contribute to high overall population mortality during the mild winter.

677. **MCCLELLAND W. T., HAIN F. P., MAWBY W. D.** 1979. Comparison of within-tree distributions and population estimation procedures for declining populations of *Dendroctonus frontalis* colonizing loblolly and shortleaf pine. Environ. Entomol. 8:1037-1040. (COLEOPTERA:

SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, DISTRIBUTION A comparison of southern pine beetle life stage distribution between loblolly and shortleaf pine in declining southern pine beetle infestations showed no difference in within-tree distribution. Similar accuracy in life stage estimation resulted from both intensive (ten sample heights/tree) and nonintensive (three sample heights/tree selected from the ten samples/tree in the intensive program) sampling procedures.

678. **MCCELLAND W. T., HAIN F. P., DEMARS C. J. JR., FARGO W. S., COULSON R. N., NEBEKER T. E.** 1978. Sampling bark beetle emergence: A review of methodologies, a proposal for standardization, and a new trap design. Bull. Entomol. Soc. Am 24:137-140. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EMERGENCE, REVIEW, MISCELLANEOUS TECHNIQUES, TRAPS AND CAGES Various techniques used to estimate bark beetle emergence are reviewed and their inherent advantages and disadvantages are discussed. A standard procedure is proposed in order to minimize bias and facilitate comparison of data among workers. A new emergence trap is introduced which should be useful for studies of bark beetles and other bark inhabiting species.

679. **MCGRAW G. W., HEMINGWAY R. W.** 1977. 6,8-dihydroxy-3-hydroxymethylisocoumarin, and other phenolic metabolites of *Ceratocystis minor*. Phytochemistry 16:1315-1316. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Ceratocystis minor*). PATHOGENS, HOST RESISTANCE, COMMENSALISM AND SYMBIOSIS Three major phenolic metabolites of *Ceratocystis minor* grown on malt agar were indicated by PC and TLC of EtOAc extracts of culture filtrates. Spectral properties indicated 6,8-dihydroxy-3-methyl-1H-2-benzopyran-1-one (compound 2) and scytalone (compound 3) were present.

680. **MCGRAW J. R., FARRIER M. H.** 1969. Mites of the superfamily Parasitoidea (Acarina: Mesostigmata) associated with *Dendroctonus* and *Ips*. N. C. Agric. Exp. Stn. Tech. Bull. No. 192. 162 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp., *Ips* spp. ACARINA: MESOSTIGMATA). MITES, TAXONOMY Keys and descriptions of 35 mites associated with *Dendroctonus* and *Ips* beetles are presented for the southeastern United States.

681. **MCMINN J. W.** 1965. Bark beetle on rampage in Virginia. For. Farmer 34(6):10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION An outbreak of the southern pine beetle in Virginia is discussed.

682. **MCNEW G. L.** 1970. The Boyce Thompson Institute Program in forest entomology that led to the discovery of pheromones in bark beetles. Contrib. Boyce Thompson Inst. 24:251-262. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). BEHAVIORAL CHEMICALS, REVIEW Reviews the role of the Boyce Thompson Institute in the discovery of bark beetle pheromones. Included are discussions of host physiology, selection of susceptible trees by bark beetles, identification of bark beetle pheromones, the role of the host-factor in attracting beetles, the natural antagonism of response to pheromones, and the future use of pheromones in bark beetle control.

683. **MEAD R. A., SMITH J. L., WARD J. G. D., GHENT J. H.** 1979. Development of a system for regional assessment of timber volume loss due to the southern pine beetle using color infrared aerial photography. *In*, Proc. 7TH Biennial Workshop on Color Aerial Photography in the Plant Sciences and Related Fields. Am. Soc. Photo. p. 137-150. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT Timber volume loss due to southern pine beetle was assessed using color infrared aerial photography.

684. **MERKEL E. P.** 1954. Southern pine beetle conditions on the Cherokee National Forest and adjoining private lands. USDA For. Serv. Southeast. For. Exp. Stn. For. Pest Survey Rep. 2. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION In the southern Appalachians, oubreaks of the southern pine beetle usually originate on ridges or dry sites.

685. **MERKEL E. P.** 1956. Bark beetle epidemics and rainfall deficiency in the Southeast. (Abstract). Assoc. South. Agric. Worker's Proc. 53:130. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Periodicity of bark beetle epidemics is reviewed; abstract only.

686. **MERKEL E. P., KOWAL R. J.** 1956. Forest insect conditions in the Southeast during 1955. USDA For. Serv. Southeast. For. Exp. Stn. Stn. Pap. No. 67, Asheville, N. C. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). CONTROL-CHEMICAL, SURVEY AND DETECTION, IMPACT, MAP The southern pine beetle was destructive during 1955 in western North Carolina and eastern Tennessee. It was in the northern counties of South Carolina and Georgia for the first time. Fifteen and one-half million board-feet of pine sawtimber and 42,000 cords of pole timber were killed by the southern pine beetle southwide in 1955. Control programs include benzene hexachloride. An outbreak map is given.

687. **MERKEL E. P., KULMAN H. M.** 1955. Beetle conditions in north-central South Carolina. South. Lumberman 190(2389):60,62. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION Aerial and ground surveys in South Carolina showed approximately 720 acres of loblolly and shortleaf pine infested amounting to a volume loss of 1,000,000 board feet over 4,000 square miles. Recommendations for control include periodic inspections, salvage, felling and burning, or spraying with 0.25% BHC in No. 2 fuel oil.

688. **MERKEL E. P., KULMAN H. M.** 1955. Southern pine beetle and pine engraver beetle conditions in north-central South Carolina. USDA For. Serv. Southeast. For. Exp. Stn. For. Insect Survey Rep. 4. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). SURVEY AND DETECTION Southern pine beetle losses in South Carolina are documented.

689. **MICHAEL R. R., RUDINSKY J. A.** 1972. Sound production in Scolytidae: Specificity in male *Dendroctonus* beetles. J. Insect Physiol. 18:2189-2201. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus pseudotsugae*, *Dendroctonus brevicomis*, *Dendroctonus ponderosae*, *Dendroctonus valens*, *Dendroctonus rufipennis*). BEHAVIORAL CHEMICALS, MORPHOLOGY AND PHYSIOLOGY The male stridulatory apparatus of six *Dendroctonus* bark beetles is described. Responses to pheromones and host terpenes were tested for *D. pseudotsugae* and *D. ponderosae*.

690. **MIDDLETON W.** 1924. Insects injurious to white pine. Bull. Green Sect. U. S. Golf Assoc. 4:148-150. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL Discusses general controls for southern pine beetles on golf courses.

691. **MILLER J. M.** 1929. The relation of windfalls to bark-beetle epidemics. Fourth Int. Congr. Entomol. Trans. 2. p. 992-1002. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). STAND CONDITIONS Two large windfall areas in California were studied from an entomological aspect. In most wind-thrown trees, part of the root system remains in the soil and some moisture is retained in the inner bark, thus producing a weakened tree with favorable conditions for bark beetle attack and brood development. When large numbers of trees are wind-thrown, conditions are favorable for massive increases in bark beetle populations. This large population usually leads to a subsequent attack on standing green trees around the windfall area.

692. **MILLER M. C.** 1979a. Development of a specific anti-adult southern pine beetle serum. Entomol. Soc. Am. Misc. Publ. 11:35-53. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips avulsus*, *Ips grandicollis*, *Ips calligraphus*). BEHAVIORAL CHEMICALS, CONTROL-CHEMICAL, MISCELLANEOUS TECHNIQUES Antibody titer values for *Dendroctonus frontalis* Zimm., *D. terebrans* (Olivier), and three *Ips* species are compared to

suggest the presence of a specific adult southern pine beetle antigen. Specific anti-adult southern pine beetle serum was produced which was genus specific in double diffusion tests, and showed no cross reactions with *Ips* antigens.

693. **MILLER M. C.** 1979. Preparatory immunodiffusion for production of specific anti-adult southern pine beetle serum. Ann. Entomol. Soc. Am. 72:820-825. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligrpahus, Ips grandicollis*). PREDATOR, PARASITES, MISCELLANEOUS TECHNIQUES Preparatory immunodiffusion was used to produce an antiserum specific for the southern pine beetle, *Dendroctonus frontalis*, and the black turpentine beetle, *D. terebrans* (Olivier). The specific antiserum did not cross react with *Ips avulsus*, *I. calligraphus*, or *I. grandicollis* when tested at high antigen concentrations. The antiserum was genus specific in all tests, and species specific when run in the agar gel double diffusion test against a standard *Dendroctonus* antigen. This antiserum can distinguish between *D. frontalis* and *D. terebrans* if it was used in an A600 test against a standard antigen.

694. **MILLER M. C.** 1981. Evaluation of enzyme-linked immunosorbent assay of narrow-and broad-spectrum anti-adult southern pine beetle serum. Ann. Entomol. Soc. Am. 74:279-282. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). MORPHOLOGY AND PHYSIOLOGY An enzyme-linked immunosorbent assay (ELISA) was conducted with broad-spectrum and specific anti-adult *Dendroctonus frontalis* sera against two-fold dilutions of 7.0 mg/ml. antigens prepared from adult southern pine beetles, black turpentine beetle, and the three *Ips* species. The broad-spectrum and specific sera differentiated between the genera and all five species. ELISA was more sensitive than agar-gel double diffusion or counter-immunoelectrophoresis with low-titer anti-insect sera.

695. **MILLER M. C., CHAPPELL W. A., GABLE W., BRIDGES J. R.** 1979. Evaluation of immunodiffusion and immunoelectrophoretic tests using a broad spectrum anti-adult southern pine beetle serum. Ann. Entomol. Soc. Am. 72:99-104. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECOLOGICAL DISTRIBUTION, MISCELLANEOUS TECHNIQUES A brood-spectrum anti-adult southern pine beetle rabbit serum was evaluated using these test systems: agar gel double diffusion, rocket electroimmunodiffusion, and counter immunoelectrophoresis. The most sensitive and rapid method was counter immunoelectrophoresis; however, crossed electroimmunodiffusion quantified and separated individual antigen-antibody systems. Laboratory and field applications of each procedure are discussed.

696. **MILLER M. C., CHAPPELL W. A., GAMBLE W. C., BRIDGES J. R.** 1978. Antiserum preparation for immunodiffusion in southern pine beetle predation studies. USDA South. For. Exp. Stn. Res. Note SO-233. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, CLERIDAE; *Thanasimus dubius*). PREDATOR, PARASITES, CONTROL-BIOLOGICAL, MISCELLANEOUS TECHNIQUES An anti-adult *Dendroctonus frontalis* serum was produced by subcutaneous injection of rabbits with southern pine beetle adult antigen. Initial tests demonstrated that the anti-adult southern pine beetle serum can detect adult southern pine beetle antigen in the body of the adult predator, *Thanasimus dubius*. Cross reactivity was found between the anti-adult serum and extracts of immature stages of *Dendroctonus frontalis* Zimm., adult *D. terebrans* (Olivier), *Ips grandicollis* (Eichoff), and *I. calligraphus* (Germar).

697. **MIZELL R. F. III.** 1977 Developmental biology of the southern pine beetle, *Dendroctonus frontalis* Zimmerman (Coleoptera: Scolytidae). M. S. Thesis, Miss. State Univ., Miss. State, Miss. 70 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). RADIOGRAPHY, EGG, LARVAE, LIFE HISTORY-GENERAL A guide developed to differentiate the instars of southern pine beetle was tested statistically by subjects with varying experience in reading radiographs. All subjects were successful in differentiating the four larval instars. Three methods for estimating the developmental rate of the southern pine beetle were tested. At high temperatures the methods were found to agree. Depending on temperature, the egg stage lasted 8 to 27 days, the larval stage from 10-62 days, and the pupal stage from 7-25 days.

698. **MIZELL R. F. III.** 1980. *Thanasimus dubius* (F.): Some behavioral factors affecting its predatory role. Ph. D. Diss., Miss. State Univ., Miss. State, Miss. 160 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus*. CLERIDAE; *Thanasimus dubius*). EGG, OVIPOSITION, PREDATOR, POPULATION DYNAMICS, SEX-RATIOS, ATTRACTANTS, REARING, MODELING, MISCELLANEOUS TECHNIQUES, MORPHOLOGY AND PHYSIOLOGY, BEHAVIOR Within-tree distribution of *Thanasimus dubius* pupation sites is described by regression models. *T. dubius* responded to several pheromones of southern pine beetle and *Ips* spp., including frontalin, ipsdienol, *alpha*-pinene, and *trans*-verbenol. *Ips avulsus* was preferred as prey over southern pine beetle and southern pine beetle was preferred over Bruchids. Peak activity periods for *T. dubius* were early morning and late afternoon. The longer the length of predator starvation the more prey the predator consumed.

699. **MIZELL R. F. III., NEBEKER T. E.** 1978. Estimating the developmental time of the southern pine beetle *Dendroctonus frontalis* as a function of field temperatures. Environ. Entomol. 7:592-595. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS, EGG, LARVAE, PUPAE The developmental time of the southern pine beetle in the field was estimated by comparing results of three methods. At high temperatures the estimates by each of the three methods were found to agree. The egg stage lasted 8-27 days, larval stage 10-62 days, and pupal stage 7-26 days. Field temperatures observed ranged between four degrees and twenty-eight degrees Celsius.

700. **MIZELL R. F. III., NEBEKER T. E.** 1979a. Differentiating the life stages of the southern pine beetle from radiographs. J. Ga. Entomol. Soc. 14:229-238. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). RADIOGRAPHY, LARVAE Larval instar determinations of *Dendroctonus frontalis* on radiographs of pine bark is presented. Pictures of radiographs are included.

701. **MIZELL R. F. III., NEBEKER T. E.** 1979b. Number of instars of the southern pine beetle (Coleoptera: Scolytidae) some comparisons of head capsule widths. Ann. Entomol. Soc. Am. 72:313-316. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LARVAE, LIFE HISTORY-GENERAL, MORPHOLOGY AND PHYSIOLOGY Larval head capsule widths, and the number of instars of the southern pine beetles found during the summer and winter in Mississippi, were compared with those of beetles from Texas, Georgia, and Virginia. Four instars occurred in all populations. Head capsules of winter larvae in Mississippi are significantly larger than those of summer larvae. In addition, summer larvae from Mississippi were significantly smaller than those of beetles from Texas, Georgia, and Virginia. Several reasons are discussed for the greater size at lower temperatures.

702. **MIZELL R. F. III., NEBEKER T. E.** 1981. Within-tree distribution of the pupae of *Thanasimus dubius* (Coleoptera: Cleridae), a predator of the southern pine beetle (Coleoptera: Scolytidae). Can. Entomol. 113:387-394. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PUPAE, PREDATOR, STATISTICAL METHODS, MODELING Within-tree pupal distributions of *Thanasimus dubius* are characterized by use of regression models. Loblolly pine contained more pupae per hundred centimeters squared of bark area than did shortleaf pine. Peak densities occurred at one to four meters height.

703. **MIZELL R. F. III., NEBEKER T. E.** 1982. Preference and oviposition rates of adult *Thanasimus dubius* (F.) on three prey species. Environ. Entomol. 11:139-143. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus*. CLERIDAE; *Thanasimus dubius*. BRUCHIDAE;

Callosobruchus maculatus). PREDATOR, FECUNDITY *Thanasimus dubius* preferred the southern pine beetle and *Ips avulsus* in feeding tests. Egg viability was lower on *T. dubius* reared on SPB.

704. **MIZELL R. F. III., NEBEKER T. E., FRAZIER J. L.** 1981. A new electro-optical activity monitor for determining locomotor activity of *Thanasimus dubius* (F.) in the laboratory. J. Ga. Entomol. Soc. 16:479-484. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, BEHAVIOR An electro-optical system is described. Results with the system indicate *Thanasimus dubius* has a diurnal activity pattern.

705. **MIZELL R. F. III., NEEL W. W., LASHOMB J. H.** 1981. Field evaluation of fenitrothion for prevention of tree mortality from southern pine beetle attack. J. Econ. Entomol. 74:30-32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL A 2% concentration of fenitrothion was as effective as 0.5% lindane in prevention of southern pine beetle attack; a 1% concentration was not.

706. **MOODY C. W.** 1980. Latest developments in southern pine beetle prevention and control. For. Farmer 39(9):22. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL The Alabama Forestry Commission is using detection flights combined with private consulting foresters working with the Commission to contact landowners with beetle-attacked timber. Salvage is started, or if not economically feasible, then trees are cut and left in place.

707. **MOON D. F. C.** 1977. Nutrient evaluation of soils associated with southern pine beetle infestations in the Upper Coastal Plains of East Texas. M. S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 62 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, SURVEY AND DETECTION A greater percentage of clay was found in the surface soil of infested plots than was found in baseline plots. Infested plots were characterized by a large percentage of sand in the subsoil. Moisture availability was significantly lower in infested plots than the baseline plots. A significant difference was found between infested baseline soil analysis in zinc content and percentage base saturation.

708. **MOORE G. E.** 1970a. Isolating entomogenous fungi and bacteria, and tests of fungal isolates against the southern pine beetle. J. Econ. Entomol. 63:1702-1703. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Beauvaria bassiana*. *Aspergillus flavus*. *Penicillium* sp. *Fusarium solani*). PREDATOR, PARASITES, PATHOGENS, CONTROL-GENERAL, CONTROL-BIOLOGICAL, REARING, MISCELLANEOUS TECHNIQUES, BACTERIA Moore describes a method to eliminate saprophytic fungal overgrowth so that internal and nonsporulating organisms can be detected in diseased insects. Ultraviolet radiation generally eliminates surface contaminants of *Dendroctonus frontalis*, as well as treatment with Hyamine 10X.

709. **MOORE G. E.** 1970b. *Dendroctonus frontalis* infection by the DD-136 strain of *Neoaplectana carpocapsae* and its bacterium complex. J. Nematol. 2(4):341-344. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. NEMATODA: *Neoaplectana carpocapsae*). PREDATOR, PARASITES, CONTROL-GENERAL, CONTROL-BIOLOGICAL, ECONOMICS, IMPACT, WEATHER RELATIONSHIPS, NEMATODES The DD-136 strain of the nematode, *Neoaplectana carpocapsae* Weiser (Steinernematidae) after spray application to pine bark in 0.1% formalin plus wetting agent, entered pine bark beetle tunnels and killed 44% of the brood and adults of *Dendroctonus frontalis* Zimm. at 18 and 26 degrees Celcius, 60% relative humidity, and at ambient temperatures and humidities. The DD-136 nematode needs a moist environment to survive in. It primarily parasitizes mature beetle larvae.

710. **MOORE G. E.** 1971. Mortality factors caused by pathogenetic bacteria and fungi of the southern pine beetle in North Carolina. J. Invertebr. Pathol. 17:28-37. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, PATHOGENS, MISCELLANEOUS TECHNIQUES, BACTERIA Phytologic agents were isolated from the broods of *Dendroctonus frontalis* collected in 1966-1968 in North Carolina. Twenty-two and one-third percent of the beetles contained pathogenic bacteria and fungal organisms.

711. **MOORE G. E.** 1972a. Southern pine beetle mortality in North Carolina caused by parasites and predators. Environ. Entomol. 1:58-65. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Thanasimus dubius*, *Scoloposcelis mississippensis*, *Roptrocerus xylophagorum*, *Coeloides pissodis*). PREDATOR, PARASITES A survey conducted in five geographical areas of North Carolina indicated that an average of 24% of *Dendroctonus frontalis* brood were parasitized and preyed upon. The more effective predators were woodpeckers, *Thanasimus dubius*, and *Scoloposcelis mississippensis*. *Roptrocerus xylophagorum* and *Coeloides pissodis* were the two parasites that made the greatest contribution to total mortality. Clerids (*Thanasimus dubius*) exhibit a density-dependent response and are the most important of the control agents.

712. **MOORE G. E.** 1972b. Microflora from the alimentary tract of healthy southern pine beetles, *Dendroctonus frontalis* (Scolytidae), and their possible relationship to pathogenicity. J. Invertebr. Pathol. 19:72-75. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LARVAE, ADULT, VECTOR, ECOLOGICAL DISTRIBUTION, DISTRIBUTION, CONTROL-GENERAL, CONTROL-BIOLOGICAL, MISCELLANEOUS TECHNIQUES, TAXONOMY, COMMENSALISM AND SYMBIOSIS, BACTERIA *Acrobacter acrogenes*, *Alcaligenes faccalis*, and *Serratia marcescens* were the principal species of bacteria, and *Aspergillus* spp. and *Penicillium* spp., the principal genera of fungi, recovered from aseptically excised fore-, mid- and hindguts of *Dendroctonus frontalis*. Seven species recovered were identical with facultative or conditional pathogens recovered from diseased beetles in other investigations.

713. **MOORE G. E.** 1972c. Pathogenicity of ten strains of bacteria to larvae of the southern pine beetle. J. Invertebr. Pathol. 20:41-45. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, PATHOGENS, CONTROL-GENERAL, CONTROL-BIOLOGICAL, BACTERIA Ten strains of bacteria were tested for pathogenicity to larvae of *Dendroctonus frontalis*. The *Bacillus* spp. (*B. cereus*, *B. thuringiensis* var. *thuringiensis* and *B. thuringiensis* var. *kenyae*, and *Pseudomonad aeruginosa*, *P. fluorescens* and *Serratia marcescens*), all from diseased beetles, were pathogenic.

714. **MOORE G. E.** 1973. Pathogenicity of three entomogenous fungi to the southern pine beetle at various temperatures and humidities. Environ. Entomol. 2:54-57. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Beauvaria bassiana*, *Aspergillus flavus*, *Fusarium solani*). ADULT, PATHOGENS, ECOLOGICAL DISTRIBUTION, SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, CONTROL-GENERAL, CONTROL-BIOLOGICAL, MISCELLANEOUS TECHNIQUES Three entomogenous fungi, *Beauvaria bassiana*, *Aspergillus flavus*, and *Fusarium solani*, were tested on adult *Dendroctonus frontalis* at temperatures ranging from 5 to 30 degrees Celsius and relative humidities of 55, 75, and 95 percent. The fungi were most pathogenic at temperatures regimes between 12 and 25 degrees C. Variation in humidity did not significantly affect mortality.

715. **MOORE G. E.** 1977. Predation and parasitism of the southern pine beetle. J. Elisha Mitchell Sci. Soc. 93. 1 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*. OSTOMIDAE; *Temnochila virescens*, *Coeloides pissodis*, *Roptrocerus xylophagorum*). PREDATOR, PARASITES, VERTEBRATES, POPULATION DYNAMICS While populations of *Dendroctonus frontalis* increased threefold from 1973-1974, parasites and predators increased only 12%. Proportion of total southern pine beetle mortality by the clerid, *Thanasimus dubius*, was density independent. Woodpeckers consumed about the same number of beetles as clerids.

716. **MOORE G. E.** 1978. Factors for determining population trends in southern pine beetle spots. Environ. Entomol. 7:335-342. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*).

POPULATION DYNAMICS, CONTROL-GENERAL, SURVEY AND DETECTION The primary predictive factor for predicting population trends of *Dendroctonus frontalis* in North Carolina and South Carolina was the attack:emergence ratio. Five secondary factors were used on static spots. The value of the technique is that it permits predictions in advance to plan and budget control tactics.

717. **MOORE G. E.** 1980. Protecting against southern pine beetles. For. Farmer 23rd Manual Ed. 39(5):96,100. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL Controls are outlined for southern pine beetle.

718. **MOORE G. E.** 1981. Southern pine beetle fact sheet number 22: Setting control priorities using emergence:attack ratios - A research update. USDA For. Serv. For. Bull. SA-FB/P 41. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, SAMPLING Emergence:attack ratios are used to set control priorities for the southern pine beetle.

719. **MOORE G. E., HERTEL G. D., BHATTACHARYYA H. T.** 1980. Emergence: attack ratio as a predictor of southern pine beetle-caused tree mortality. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 169-171. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING Several predictive population models based on emergence: attack ratios are developed in order to estimate the 4-month tree mortality in individual spots. One linear and four logarithmic models were derived, and the logarithmic models gave the best fit.

720. **MOORE G. E., LAYMAN H. F.** 1978. Attempts to increase resistance of loblolly pines to bark beetles by fertilization. USDA For. Serv. Res. Note SE-260. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*). HOST RESISTANCE, CONTROL-CHEMICAL, CONTROL-CULTURAL Applications of 10-10-10 fertilizer (1000 lbs./acre) did not signifcantly increase the resistance of 9- to 11-year old loblolly pines to attack by *Dendroctonus frontalis* or *D. terebrans*.

721. **MOORE G. E., TAYLOR J. F.** 1976. Tagging of the southern pine beetle with Phosphorus 32. Environ. Entomol. 5:1065-1067. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FLIGHT, RADIOGRAPHY, TRAPS AND CAGES, MISCELLANEOUS TECHNIQUES A technique for tagging southern pine beetles with a radioisotope is discussed. An aqueous glycerine suspension of ^{32}P was applied to the bark of infested bolts before beetle emergence. Emerging beetles picked up the isotope and carried it to the new host bolt where it was detected in the pitch tube.

722. **MOORE G. E., TAYLOR J. F., SMITH J.** 1979. Tracing dispersion of southern pine beetles from felled brood trees with Phosphorus 32. J. Ga. Entomol. Soc. 14:83-87. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FLIGHT, HOST SELECTION, MISCELLANEOUS TECHNIQUES Radio-tagging with ^{32}P was used to trace southern pine beetles dispersing from one infestation to another. Infestation of nearby trees was heavier with the cut-and-top as compared to the cut-and-leave method. Beetles dispersed up to 365 m.

723. **MOORE G. E., THATCHER R. C.** 1973a. Epidemic and endemic populations of the southern pine beetle. USDA For. Serv. Res. Pap. SE-111. 11 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, CONTROL-GENERAL, WEATHER RELATIONSHIPS The differences between epidemic and endemic populations of *Dendroctonus frontalis* in two distinctly different geographical areas are defined and the varied beetle activity in these areas is discussed. Factors that favor epidemic beetle populations are prolonged moisture stress in trees, slow growth and dense stands, poor drainage, low soil fertility, and excessive damage to residual stands. Factors that favor endemic populations are weather conditions that promote long-term growth of trees, pathogens, intraspecific and interspecific competition, and the production of natural attractants out of phase with emergent brood adults.

724. **MOORE G. E., THATCHER R. C.** 1973b. How safe are your pines from bark beetles? For. Farmer 32(3):12-13,18. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, CONTROL-GENERAL, SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES, WEATHER RELATIONSHIPS Moore and Thatcher provide answers to questions about southern pine bark beetle controls/threats for pines. They provide basic information for the layman on 1) identification of attacked pines, 2) the importance of timing control cycles with the beetle's life cycle, and 3) the status of the southern pine beetle in 1972.

725. **MOORE K. R.** 1979. Distributions of three species of *Ips* bark beetles within southern pine beetle infestations. M. S. For. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 37 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). DISTRIBUTION, FLIGHT, AGGREGATION Distribution patterns of three species of *Ips* bark beetles and the southern pine beetle were characterized within southern pine beetle infestations. All four species exhibited aggregation within their spatial distributions. The southern pine beetle and *Ips* calligraphus showed no significant difference in their diurnal distribution with peak flight activity occurring around 1700 hours. The most active flight activity for *I. grandicollis* occurred in late afternoon and evening. Low morning activity with a peak at 1600 hours characterized the flight activity of *I. avulsus*.

726. **MOORE L. M.** 1977. Effects of the phloem-mobile systemic insecticide acephate on the southern pine beetle, *Dendroctonus frontalis* Zimmerman, populations in loblolly pines, *Pinus taeda* L., in Grant and Rapides Parishes, Louisiana. M.S. Thesis Univ. Mich., Ann. Arbor, Mich. 34 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL The effects of systemic acephate on the southern pine beetle were tested.

727. **MORI K.** 1975. Synthesis of optically active forms of frontalin: The pheromone of *Dendroctonus* bark beetles. Tetrahedron 31(11/12):1381-1384. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, MISCELLANEOUS TECHNIQUES (R)-(+)-Frontalin (1) and its antipode (1') were synthesized from (R)-(+)-2-hydroxy-2-methylpentane-1,5-dioic acid 5 – 2 lactone (2) and its antipode (2'), respectively. This synthesis established the absolute enantiomeric configuration of frontalin.

728. **MORI K.** 1976. A stereoselective synthesis of (±)-*endo*-brevicomin, a pheromone inhibitor produced by *Dendroctonus* bark beetles. Agric. Biol. Chem 40:2499-2500. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*). BEHAVIORAL CHEMICALS, ATTRACTANTS Mori describes a new and highly stereoselective synthesis of *endo*-Brevicomin, a pheromone inhibitor produced by *Dendroctonus* bark beetles.

729. **MORI K., KOBAYASHI S., MATSUI M.** 1975. A synthesis of (±)-frontalin, the pheromone of *Dendroctonus* bark beetles. Agric. Biol. Chem. 39:1889-1890. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS Discusses the synthesis of (±) frontalin.

730. **MORRIS C. L.** 1979. Southern pine beetle control: Needs and expectations of the small forest landowner. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 5-7. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT The problems, needs, and expectations of small forest landowners are discussed in relation to attempts to implement certain management practices on their woodland acreage. The role of industrial, Federal, State and private forests in this implementation are discussed.

731. **MORRIS C. L., COPONY J. A.** 1974. Effectiveness of intensive salvage in reducing southern pine beetles in Virginia. J. For. 72:572. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, CONTROL-CULTURAL Intensive salvage programs reduced southern pine beetle populations on the Cumberland State Forest in Virginia in 1973-1974.

732. **MORRIS C. L., SWAIN K. M.** 1978. Predicting southern pine beetle attacks. For. Farmer 37(3):11-12. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, REVIEW, LIGHTNING Increased susceptibility to attack by the southern pine beetle is precipitated by poor site quality, natural disturbances such as lightning, injury through logging and road building , poor soil moisture relationships, and diseases.

733. **MOSER J. C.** 1975. Mite predators of the southern pine beetle. Ann. Entomol. Soc. Am. 68:1113-1116. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. ACARINA). PREDATOR, PARASITES, CONTROL-GENERAL, CONTROL-BIOLOGICAL, MITES Four out of 51 species of mites associated with *Dendroctonus frontalis* are primary candidates for use as natural control agents. These are: *Histiogaster arborsignis*, *Proctolaelaps dendroctoni*, *Macrocheles boudreauxi* and *Dendrolaelaps neodisetus*. Four secondary candidates are listed.

734. **MOSER J. C.** 1976a. Phoretic carrying capacity of flying southern pine beetles (Coleoptera: Scolytidae). Can. Entomol. 108:807-808. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Trichouropoda australis*). PREDATOR, PARASITES, FLIGHT, COMMENSALISM AND SYMBIOSIS, MITES Of 2539 trapped southern pine beetles, 23.3% possessed at least one deutonymph of *Trichouropoda australis*, with an average of 4.9 per male and 5.1 per female southern pine beetle.

735. **MOSER J. C.** 1976b. Surveying mites (Acarina) phoretic on the southern pine beetle (Coleoptera: Scolytidae) with sticky traps. Can. Entomol. 108:809-813. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, TRAPS AND CAGES, MITES Seven species of phoretic mites were retrieved from southern pine beetles caught on sticky traps. Of 2539 southern pine beetles surveyed, 39.6 percent carried mites. The two most common species, *Tarsonemus krantzi* and *Trichouropoda australis* showed no sex preference for riding on beetles, but rode on specific parts of the body.

736. **MOSER J. C.** 1979. Parasitengona mites (Acarina: Prostigmata) associated with flying adults of the southern pine beetle. Int. J. Acar. 5:24-28. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. ACARINA: PROSTIGMATA; *Leptus* spp., *Balaustium* spp., *Eutrombicula* spp., *Diathrombium* spp.). PREDATOR, PARASITES, ATTRACTANTS, MITES All motile instars (larva, nymph, and adult) of three Parasitengona families, Erythraeidae, Trombidiidae, and Trombiculidae, were taken from pheromone traps for *Dendroctonus frontalis*. The mites rode on the southern pine beetle and were active in the warm months. These mites apparently attach themselves to beetles during or shortly after emergence.

737. **MOSER J. C., BROWNE L. E.** 1978. A nondestructive trap for *Dendroctonus frontalis* Zimmerman (Coleoptera: Scolytidae). J. Chem. Ecol. 4:1-7. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEX-RATIOS, BEHAVIORAL CHEMICALS, TRAPS AND CAGES The bucket trap for collecting the southern pine beetle is discussed. The trap has three major advantages: 1) it is not messy like sticky traps, 2) it is not cumbersome like conventional live traps, and 3) it is lightweight. Included are photographs and discussions on usage and hints for better trapping.

738. **MOSER J. C., CROSS E. A.** 1975. Phoretomorph: A new phoretic phase unique to the Pyemotidae (Acarina: Tarsonemoidea). Ann. Entomol. Soc. Am. 68:820-822. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. ACARINA: PYREMOTIDAE; *Siteroptes* spp.). MITES The phoretomorph represents a new type of phoresy commonly associated with bark beetles and other insects.

739. **MOSER J. C., CROSS E. A., ROTON L. M.** 1971. Biology of *Pyemotes parviscolyti* (Acarina: Pyemotidae). Entomophaga 16:367-379. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. ACARINA: PYEMOTIDAE; *Pyemotes parviscolyti*). PREDATOR, PARASITES, TAXONOMY, MITES The mite *Pyemotes parviscolyti* is phoretic on *Pityophthorus bisulcatus*. It attacks all life stages except the adult. The mites were found on pupae of *Dendroctonus frontalis* in the laboratory.

740. **MOSER J. C., DELL T. R.** 1979. Predictors of southern pine beetle flight activity. For. Sci. 25:217-222. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, BEHAVIORAL CHEMICALS, FLIGHT, TRAPS AND CAGES, WEATHER RELATIONSHIPS An equation based on weather data explained differences in capture counts of pine bark beetles trapped twice weekly for one year in a single infestation. The proportion of trapped beetles increased with maximum temperature and decreased with heavy precipitation.

741. **MOSER J. C., DELL T. R.** 1980. Weather factors predicting flying populations of a clerid predator and its prey, the southern pine beetle. Proc. Second IUFRO Conf., Sandpoint, Idaho, Berryman A.A. and Safranyik L., Eds., Dispersal of forest insects: Evaluation, theory, and management implications, Coop. Ext. Serv., Wash. State Univ., Pullman, Wash. p. 266-278. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, SEASONAL OCCURRENCE, DISTRIBUTION, CONTROL-BIOLOGICAL, WEATHER RELATIONSHIPS In endemic situations the clerid beetle, *Thanasimus dubius*, suppresses southern pine beetle populations.

742. **MOSER J. C., KIELCZEWSKI B., WISNIEWSKI J., BALAZY S.** 1978. Evaluating *Pyemotes dryas* (Vitzthum 1923) (Acari: Pyemotidae) as a parasite of the southern pine beetle. Int. J. Acar. 4:67-70. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*. ACARINA: PYEMOTIDAE; *Pyemotes dryas*). PREDATOR, PARASITES, CONTROL-BIOLOGICAL Two shipments of *Pyemotes dryas* (Vitzthum 1923), from Poland were studied in Pineville, Louisiana, to determine parasitic tendencies on southern pine beetle, *Dendroctonus frontalis* Zimm., and six associated beetles. In spite of phoretic tendencies on European bark beetles, *P. dryas* was never observed to ride on *Dendroctonus frontalis* or the six other associated beetles.

743. **MOSER J. C., ROTON L. M.** 1971. Mites associated with southern pine bark beetles in Allen Parish, Louisiana. Can. Entomol. 103:1775-1798. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*. ACARINA). PREDATOR, PARASITES, MISCELLANEOUS TECHNIQUES, TAXONOMY, COMMENSALISM AND SYMBIOSIS, MITES Ninety-six species of mites were associated with the southern pine beetle in an infestation in Allen Parish, Louisiana. The mites were evaluated to determine which species may be of value as biological agents.

744. **MOSER J. C., THATCHER R. C., PICKARD L. S.** 1971. Relative abundance of southern pine beetle associates in East Texas. Ann. Entomol. Soc. Am. 64:72-77. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). ECOLOGICAL DISTRIBUTION, SEASONAL OCCURRENCE, DISTRIBUTION, CONTROL-GENERAL, CONTROL-BIOLOGICAL, TAXONOMY More than 90 species of insects were identified in bolts taken from East Texas loblolly pines infested by the southern pine beetle and *Ips* engraver beetles. The seasonal abundance of the associates is discussed.

745. **MOSER J. C., VERCAMMEN-GRANDJEAN P. H.** 1979. *Megophthrombium gracile* n.sp. and *Diathrombium diaphane* n.g., n.sp. (Acarina: Trombidiidae), two larval parasites of adult southern pine beetles. Int. J. Acar. 5:18-23. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. ACARINA: TROMBIDIIDAE). PREDATOR, PARASITES, TAXONOMY, MITES Descriptions and illustrations of one new genus and two new species, both recovered as parasites of the southern pine beetle, (*Dendroctonus frontalis* Zimm.) are presented.

746. **MOSER J. C., WILKINSON R. C., CLARK E. W.** 1974. Mites associated with *Dendroctonus frontalis* Zimmerman (Scolytidae: Coleoptera) in Central America and Mexico. Turrialba 24(4):379-381. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, TAXONOMY, MITES Fifty-seven species of mites were collected from the southern pine beetle. The value of several species as biocontrol agents is discussed.

747. **MOTAMEDI M.** 1981. Sensitivity analysis applied to the simulation model of *Dendroctonus frontalis* Zimm. Ph. D. Diss., Univ. Arkansas, Fayetteville, Ark. 216 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, MISCELLANEOUS TECHNIQUES Two methods were developed to evaluate the degree of sensitivity of the simulation model of *Dendroctonus frontalis*. One method computes the change in the number of dead trees over the entire period of prediction. The second method evaluates the change in number of dead trees on the last day of prediction.

748. **MOTT R. L., THOMAS A.** 1977. Pine beetles raised in lab. Res. Farming N. C. Agric. Exp. Stn. 35:9. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REARING In order to overcome observational problems of the southern pine beetle, a system was developed to raise southern pine beetle in the lab. Pine cells are cultured under sterile conditions and the tissue resulting serves as a beetle food source. Original egg to adult rearing has been low but has occurred. With research this may open new avenues for southern pine beetle experimentation.

749. **MOTT R. L., THOMAS H. A., NAMKOONG G.** 1978. In vitro rearing of southern pine beetle larvae on tissue-cultured loblolly pine callus. Ann. Entomol. Soc. Am. 71:564-566. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LARVAE, REARING, COMMENSALISM AND SYMBIOSIS, EGG A technique is presented for aseptically rearing *Dendroctonus frontalis* from egg to adult in a subcultured loblolly pine (*Pinus taeda*) callus medium. Of the three systems tried, callus on 3% nutrient agar solution resulted in the highest percentage of hatched larvae. The effect was enhanced by the addition of *beta*-sitosterol to the culture medium.

750. **MUESEBECK C. F. W.** 1938. The Genus *Dendrosoter* Wesmael in the United States (Hymenoptera: Braconidae). Proc. Entomol. Soc. Wash. 40(9):281-287. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus. Dendrosoter sulcatus*). TAXONOMY, PARASITES The wasp *Dendrosoter sulcatus* is described; it is parasitic on *Dendroctonus frontalis* and *Ips avulsus*.

751. **MURPHY L. S.** 1917. The red spruce: Its growth and management. USDA Bull. No. 544. p. 26-29. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL The southern pine beetle attacks red spruce; controls include felling and burning, placing infested material in water, and using the infested material.

752. **NAGEL W. P.** 1959. Forest insect conditions in the Southeast during 1958. USDA For. Serv. Southeast. For. Exp. Stn. Stn. Pap. No. 100, Asheville, N.C. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, WEATHER RELATIONSHIPS The southern pine beetle was at a low ebb in 1959; over 95% of the brood had been killed by low temperatures.

753. **NAMKOONG G.** 1979. The dynamics of population genetics in forest insects. *In*, Population Dynamics for Insects at Low Levels., Work Conf. Aug. 1979, N. C. State Univ., F. P. Hain Ed. p. 6-8. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING, GENETICS A descriptive model of the genetic dynamics of forest insect species that undergo cyclical epidemics is presented. Genetic drift is assumed to underlie endemic population's response to selection pressures and variance in gene frequency. When one or more endemic populations with advantageous gene collections experience a combination of favorable environmental factors in such a manner that rapid population growth occurs, an epidemic results. The application of this model to southern pine beetle populations is discussed.

754. **NAMKOONG G., ROBERDS J. H., NUNNALLY L. B., THOMAS H. A.** 1979. Isozyme variations in populations of southern pine beetles. For. Sci. 25:197-203. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, MORPHOLOGY AND PHYSIOLOGY, GENETICS An isozyme analysis of five enzyme systems in *Dendroctonus frontalis* and *D. brevicomis* indicated genetic differences among geographically distant beetle populations. Georgia, Arizona and Texas populations exhibited considerable differences among each other and with populations from Virginia, North Carolina and Louisiana. *D. frontalis* from Arizona is quite different from that of the southeastern United States. A Virginia-North Carolina-Louisiana axis appears to exist. Three of the five enzyme systems studied (adenylate kinase, esterase and glucose phosphate isomerase) exhibited isozyme differences.

755. **NASH C. R. JR.** 1970. The use of a synthetic attractant as a survey instrument for the southern pine beetle, *Dendroctonus frontalis* Zimmerman. M. S. Thesis, Tex. A&M Univ., College Station, Tex. 55 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, SURVEY AND DETECTION This study represents the first attempt to use frontalin, the population aggregating pheromone of the southern pine beetle as a survey tool. Various frontalin-baited traps were tested, the most successful being a mailing tube coated with 'Stickem' and equipped with plastic vial caps containing the pheromone. It was shown that southern pine beetle can be lured to non-host trees and small trees unsuitable for brood production which may show promise for future use in control practices.

756. **NEBEKER T. E.** 1979. Additional considerations in evaluating tactics for southern pine beetle control. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30 - Feb 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 98-105. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, MODELING, IMPACT, STAND CONDITIONS Procedures for estimating absolute within-tree populations of southern pine beetles are presented and reviewed. Cost, precision and accuracy factors are considered. The individual tree, site and stand conditions, and the system's ecology are considered in the evaluation of control tactics.

757. **NEBEKER T. E.** 1981 How to interpret radiographs of bark samples from beetle-infested pines. USDA Comb. For. Pest Res. and Dev. Prog. Agric. Handb. No. 577. 14 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). RADIOGRAPHY Radiographs interpretation for tree discs for bark beetle inclusions are presented. Larvae, pupae, galleries and competition between species are depicted.

758. **NEBEKER T. E., HACKNEY O. P., HOCKING R. R.** 1981. Indirect estimation of southern pine beetle (Coleoptera: Scolytidae) gallery length utilizing host characteristics. Can. Entomol. 113:199-203. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING Southern pine beetle gallery length was estimated using tree diameter, length of infested bole, total tree height, inner bark thickness, and the appropriate model for the time of year.

759. **NEBEKER T. E., HACKNEY O. P., HOCKING R. R., PAZ M., LASHOMB J. H.** 1978. Methods for and comparison of sampling schemes for estimating within tree southern pine beetle populations (Coleoptera: Scolytidae). Can. Entomol. 110:1015-1022. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, STATISTICAL METHODS For equal sampling areas, relative efficiency (ratio of variances) increases with decreasing sample unit size and unequal stratification allocating smaller areas to the upper and lower areas of the infested bole.

760. **NEBEKER T. E., HOCKING R. R., HACKNEY O. P., LASHOMB J. H.** 1978. A comparison of non-linear and linear models for describing gallery length distribution of *Dendroctonus frontalis* attacking shortleaf pine. Environ. Entomol. 7:636-640. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). OVIPOSITION, ECOLOGICAL DISTRIBUTION, HOST SELECTION, MODELING Non-linear and linear models were compared to see how well they described the within-tree egg gallery-distribution of southern pine beetle attacking shortleaf pines. A new model is proposed, which would improve upon former models proposed by Coulson et al., Foltz et al., and Mayyasi et al.

761. **NEBEKER T. E., MIZELL R. F. III.** 1980. Behavioral considerations in quantifying the impact of *Thanasimus dubius* (F.) adults on bark beetle populations. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980.

Asheville N.C., Stephen F. M., Searcy J . L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 98-108. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp. CLERIDAE; *Thanasimus dubius*). PREDATOR, PARASITES, BEHAVIOR *Thanasimus dubius* responds to the pheromones of *Dendroctonus frontalis* and *Ips*. Satiated adult *T. dubius* prefer *Ips* in the laboratory. When starved, no preference is manifested. Once a host tree is located, the number of prey attacked is dependent on the time elapsed since the last meal. Influencing factors, a predictive model, and the functional response of *T. dubius* are discussed.

762. **NEBEKER T. E., PURSER G. C.** 1980. Relationship of temperature and prey type to developmental time of the bark beetle predator *Thanasimus dubius* (Coleoptera: Cleridae). Can. Entomol. 112:179-184. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp. CLERIDAE; *Thanasimus dubius*). PREDATOR, PARASITES, DISTRIBUTION, REARING, WEATHER RELATIONSHIPS Lab studies of developmental rates of *Thanasimus dubius* larvae fed on three prey types (small larvae, large larvae and pupae of the southern pine beetle) under three temperature regimes indicate a decreasing developmental time with increasing temperature (ca. 87 days at 15 C to 35 days at 27 C), a longer developmental time when fed small larvae (3.7 days average), but no differences between larvae fed on large larvae or pupae.

763. **NEBEKER T. E., PURSER G. C., MIZELL R. F. III.** 1980. Collection and maintenance of *Thanasimus dubius* (F.) for biological and behavioral studies. J. Ga. Entomol. Soc. 15:406-412. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, REARING Recommendations are made for collecting and maintaining the clerid, *Thanasimus dubius*, in the laboratory.

764. **NELSON R. M.** 1934. Effect of bluestain fungi on southern pines attacked by bark beetles. Phytopathol. Z. 7(4):327-353. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). VECTOR, PATHOGENS, HOST RESISTANCE Nelson reviews the relationship of *Dendroctonus frontalis* to bluestain fungi. Experiments with *Ceratostomella pini* and *C. ips* are reviewed. Water relationships were discussed in relation to the fungi as was the relationship of tori in stained and unstained wood. Nelson stated that the bluestain fungi plus the beetles resulted in the death of the tree.

765. **NELSON R. M., BEAL J. A.** 1929. Experiments with bluestain fungi in southern pines. Phytopathology 19(12):1101-1106. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, COMMENSALISM AND SYMBIOSIS Bluestain fungi, combined with the wounding which accompanies inoculation, may kill pine trees fairly quickly. The authors believe that bluestain fungi may play a significant role in the death of pines attacked by southern pine beetle.

766. **NETTLES W. C.** 1959. Insect and plant disease handbook, South Carolina. Clemson Agric. Coll. Bull. 114. p. 131. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CONTROL-CHEMICAL Gives a brief description of life history and control of southern pine beetle with BHC.

767. **NEWELL W.** 1904. Insect notes from Georgia for the year 1903. USDA Div. Entomol. Bull. No. 46. p. 103-105. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Brief note of the southern pine beetle near Cornelia, Georgia.

768. **NEWTON C. M., LEUSCHNER W. A.** 1973. Impact of the southern pine bark beetle on stand productivity and values. *In*, Southern pine beetle - A management challenge. Entomol. Soc. Am. Natl. Meet., Dallas, Tex., Nov. 28, 1973. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, REVIEW, WOOD UTILIZATION, INTEGRATED PEST MANAGEMENT The justification of any control program should be based on the insect's impact of the host's utility. A program should enhance forest utility by reducing the pest's damage leading to increased benefits. Potential impact of the southern pine beetle on timber includes mortality, reduced growth, and disruption of timber management planning. Possible benefits from the southern pine beetle include natural thinning of stands.

769. **OATES K. M.** 1978. Fertilization as a direct control of an epidemic population of southern pine beetle (*Dendroctonus frontalis* Zimm.) in a shortleaf pine (*Pinus echinata* Mill.) stand. M. S. Thesis, N. C. State Univ., Raleigh, N. C. 72 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, MISCELLANEOUS TECHNIQUES The effects of fertilization as a possible control for epidemic populations of southern pine beetle were investigated. Three replicates of paired plots were established in pine plantations. One of each pair was fertilized, the other left as a control. Results suggest that trees were attacked because of their position in the stand and that beetles showed preference for the non-fertilized trees.

770. **OHRUI H., EMOTO S.** 1976. A synthesis of (S)-(-)-Frontalin from D-glucose. Agric. Biol. Chem. 40:2267-2270. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). BEHAVIORAL CHEMICALS The synthesis of (S)-(-)-Frontalin, a *Dendroctonus* pheromone, from D-glucose is described.

771. **OLLIEU M. M.** 1969. Evaluation of alternative southern pine beetle control techniques. Tex. For. Serv. Pest Control Sec. Sec. Publ. 104. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CHEMICAL, CONTROL-CULTURAL Several alternative control tactics were evaluated against the southern pine beetle: cacodylic acid, cut-and-leave, and cut-and-top. The application of cacodylic acid through axe frills in the boles of attacked trees was the most effective treatment for controlling southern pine beetle brood production.

772. **OLLIEU M. M., MASON G. N.** 1967. Forest pest activity in Texas-1967. Tex. For. Serv. Circ. No. 109. 11 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). SURVEY AND DETECTION, ECONOMICS, IMPACT A survey of forest pest activity and control efforts in Texas during 1967 is presented; including forest insects, forest diseases, and animal pests.

773. **OLLIEU M. M., MASON G. N.** 1968. Forest pest activity in Texas-1968. Tex. For. Serv. Circ. No. 113. 13 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Dendroctonus brevicomis, Dendroctonus pseudotsugae, Ips avulsus, Ips calligraphus, Ips grandicollis*). SURVEY AND DETECTION, ECONOMICS, IMPACT A survey of forest pest activity and control efforts in Texas during 1968 is presented.

774. **ORDISH G.** 1966. Pine bark beetle in Honduras. SPAN 9:121-123. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The occurrence of the southern pine beetle in Honduras is documented.

775. **ORR L. W., KOWAL R. J.** 1956. Progress in forest entomology in the South. J. For. 54:653-656. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL, SURVEY AND DETECTION, REVIEW A review of forest insect pests in the South and the progress being made by entomologists in dealing with this problem is presented. Several categories of pests are reviewed; such as products insects, insects that hinder regeneration, defoliators, bark beetles, and hardwood insects. Aerial and ground surveys provide accurate information on outbreaks of pest populations. Investigations on insect behavior and biology are strongly recommended by the author.

776. **ORTIZ J. H.** 1980. The effect of cut-top control tactics on within-tree survival of southern pine beetle, *Dendroctonus frontalis* Zimm., and its natural enemies. M.S. Thesis Univ. Arkansas, Fayetteville. 111 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, PREDATOR, PARASITES, POPULATION DYNAMICS Cut-and-top tactics significantly reduced southern pine beetle populations.

777. **OSGOOD E. A.** 1957. A bibliography on the southern pine beetle *Dendroctonus frontalis* Zimm. USDA For. Serv.

Southeast. For Exp. Stn. Stn. Pap. No. 80, Asheville, N. C. 19 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW Bibliography of the southern pine beetle prior to 1957.

778. **OSGOOD E. A. JR., CLARK E. W.** 1963. Methods of sexing and sex ratios of the southern pine beetle, *Dendroctonus frontalis* Zimm. Can. Entomol. 95:1106-1109. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEX-RATIOS, MORPHOLOGY AND PHYSIOLOGY Several criteria for determining the sex of the southern pine beetle were investigated. The best criterion for sexing the beetles is the combination of the prominence of the frontal tubercles and depth of the frontal groove.

779. **OSTMARK H. E., BENNETT W. H.** 1971 (rev.) This is Fannie Frontalis - your dying pines may have met her. USDA For. Serv. Southeast. For Exp. Stn. 18 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*; *Ips* spp.). LIFE HISTORY-GENERAL, CONTROL-GENERAL, CONTROL-CHEMICAL, CONTROL-CULTURAL You too can beat the beetle! Fannie, a native of the Southern (United) States, thrives in hot, dry weather. She loves neglected, overdense stands. Her bark galleries are s-shaped (a true Southerner). Fannie can convert your thrifty pine stands into patches of dying pines in nothing flat. You can stop Fannie by cutting the logs and taking them to the mill pronto or by spraying lindane (careful, follow label instructions). She was cited in recognition of being the worst bark beetle pest in southern pine forests.

780. **OVERGAARD N. A.** 1968. Insects associated with the southern pine beetle in Texas, Louisiana, and Mississippi. J. Econ. Entomol. 61:1197-1201. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Roptrocerus ecoptogastri*, *Cecidostiba dendroctoni*, *Medetera maura*). COMPETITION, PREDATOR, PARASITES, REARING, TAXONOMY Laboratory rearings were carried out in three southern states during 1963-1965, and 84 insect species were found associated with the southern pine beetle. Of these, seven were known predators and eight were known parasites of the southern pine beetle. The most abundant hymenopterous parasite collected was a torymid, *Roptrocerus ecoptogastri*, while *Medetera maura*, a dolichopodid, was one of the most prevalent predators.

781. **OVERGAARD N. A.** 1970. Control of the southern pine beetle by woodpeckers in central Louisiana. J. Econ. Entomol. 63:1016-1017. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Dryocopus pileatus*, *Dendrocopus pubescens*, *Centurus carolinus*). PREDATOR, PARASITES, CONTROL-BIOLOGICAL Three species of woodpeckers (pileated, downy, and red bellied) were responsible for a 24.4%reduction in southern pine beetle brood in southern pine trees. In spite of woodpecker-related mortality, much of the brood in bark chips dislodged by woodpeckers was expected to emerge and reinfest standing trees when temperatures increased significantly.

782. **O'BYRNE W.** 1946. Pine bark beetles or "Bugs". Va. Polytech. Inst. and USDA Coop., Circ. 403. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL Brief description of bark beetles in pines.

783. **PABST G. S., SIKOROWSKI P. P.** 1980. Susceptibility of southern pine beetle (*Dendroctonus frontalis*) on oligidic medium to *Paecilomyces viridis* and also *Beauvaria bassiana*, and *Metarhizium anisopliae*. J. Ga. Entomol. Soc. 15:235-241. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Beauvaria bassiana*, *Paecilomyces viridis*, *Metarhizium anisopliae*). PATHOGENS, CONTROL-BIOLOGICAL Late instar larvae of *Dendroctonus frontalis* were tested on oligidic medium for susceptibility to three entomogenous fungi. The LD_{50} values for the fungi were: *Beauvaria bassiana* 1200, *Paecilomyces viridis* 1500, and *Metarhizium anisopliae* 7300 spores per larva, respectively. The authors concluded that microscopic counts alone are poor predictors of infectivity rates; other criteria such as germination of spores should be included.

784. **PAGE R. H. JR., MILLSAPS P. G.** 1941. Farm Forestry. Handb. of Ala. Agric. Ala. Polytechnic Instit. Ext. Serv. p. 147-161. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL Summarizes life history and control of the southern pine beetle.

785. **PAINE T. D., BIRCH M. C., ŠVIHRA P.** 1981. Niche breadth and resource partitioning by four sympatric species of bark beetles (Coleoptera: Scolytidae). Oecologia 48:1-6. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). COMPETITION, ECOLOGICAL DISTRIBUTION *Dendroctonus frontalis*, *Ips calligraphus*, *I. grandicollis*, and *I. avulsus* are sympatric species in southeastern North America. Using niche breadth and overlap indices, the interaction of beetle species in sharing phloem tissue within whole trees and sample levels was examined. Species diversity was highest in the mid-bole and steadily decreased toward the stump and crown. Increased diversity showed a positive correlation with increasing niche overlap.

786. **PALMER H. C.** 1975. Evaluation of high temperature upon survival of the southern pine beetle (Coleoptera: Scolytidae) in loblolly pine. M. S. For. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 78 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CULTURAL, WEATHER RELATIONSHIPS Emergence of beetles was four percent less from felled pines than from standing pines. This level of reduction was not felt sufficient to justify the cut-and-leave method as a supplemental method of control for the southern pine beetle.

787. **PALMER H. C. JR., COSTER J. E.** 1978. Survival of southern pine beetles in felled and standing loblolly pines. J. Ga. Entomol. Soc. 13:1-7. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CULTURAL, WEATHER RELATIONSHIPS In laboratory investigations, southern pine beetle egg gallery lengths and number of egg niches per gallery declined above 30 degrees Celsius. Mortality of adult beetles exposed to 40, 44 and 48 degrees Celsius occurred after 40, 16 and 8 hours, respectively. Larvae were more heat tolerant than adults. Pine trees felled (cut-and-leave) showed 66% brood reduction compared to standing trees.

788. **PASE H. A., FAGALA E. P.** 1979. A computer-based informational system to aid southern pine beetle control operations. Tex. For. Serv. Publ. No. 120. 21 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The Texas Forest Service developed and implemented a computer-based informational system to monitor *Dendroctonus frontalis* detection, ground check and control operations in East Texas on private and state forest lands. Flow charts, field report forms, ground check reports, detection reports, and control reports are outlined and discussed. Output information from the system is described, and its administration is explained.

789. **PATTERSON D. W.** 1978. Wood degrade after death from southern pine beetle attack. For. Prod. Notes 3(11)1-4. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION In 1977, the Texas Forest Products Laboratory investigated lumber degrade associated with southern pine beetle pines. Trees dead for a year had deep checks and decay. No attempt was made to do a plywood recovery study due to the advanced checking.

790. **PAYNE T. L.** 1970. Electrophysiological investigations on response to pheromones in bark beetles. Contrib. Boyce Thompson Inst. 24:275-282. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEX-RATIOS, BEHAVIORAL CHEMICALS, MORPHOLOGY AND PHYSIOLOGY, ATTRACTANTS Electroantennograms (EAG) of southern pine beetle and western pine beetle response to frontalin, brevicomin, and the host tree terpenes *alpha*-pinene and 3-carene indicated that antennae are not specific to the pheromones and host terpenes, but differential responsiveness between species and sexes within species were detected. Southern pine beetle males were more responsive than females to frontalin, while western pine beetle males were more responsive than females to brevicomin and western pine beetle females were more responsive than males to frontalin.

791. **PAYNE T. L.** 1971. Bark beetle olfaction. I. Electroantennogram responses of the southern pine beetle (Coleoptera: Scolytidae) to its aggregation pheromone frontalin.

Ann. Entomol. Soc. Am. 64:266-268. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MISCELLANEOUS TECHNIQUES, MORPHOLOGY AND PHYSIOLOGY Antennal olfactory responsiveness by *Dendroctonus frontalis* is recorded through electroantennogram readings. Both male and female antennae responded equally as female aggregating pheromone was used in increasing concentrations. Since frontalin produces electrophysiological and behavioral responses from both the male and female equally, it is believed that frontalin is an aggregation and not a sex pheromone.

792. **PAYNE T. L.** 1973a. Pheromone and host odor-stimulated potentials in *Dendroctonus*. Experientia 30:509-510. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*). BEHAVIORAL CHEMICALS, MISCELLANEOUS TECHNIQUES, MORPHOLOGY AND PHYSIOLOGY, BEHAVIOR Two species of *Dendroctonus*, *D. frontalis* and *D. brevicomis*, displayed antennal raising and orientation movements when stimulated by the pheromones frontalin and *exo*-brevicomin and the host tree terpenes *alpha*-pinene and 3-carene.

793. **PAYNE T. L.** 1973b. The southern pine beetle is alive and smelling. For. Farmer 32(11):14. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, CONTROL-CHEMICAL The use of pheromones for manipulation of southern pine beetle populations is discussed.

794. **PAYNE T. L.** 1974a. Olfactory perception by the southern pine beetle. *In*, Southern Pine Beetle Symp., Payne T. L., Coulson R. N., Thatcher R. C., Eds. March 7-8, 1974. Tex. Agric. Exp. Stn., College Station, Tex. p. 41-44. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, MORPHOLOGY AND PHYSIOLOGY The olfactory perception system is explained. Diagrams showing sensilla and response monitoring are included. Pheromone and host volatiles as well as aggregation and inhibition are also discussed.

795. **PAYNE T. L.** 1974b. Pheromone perception. *In*, Pheromones., Chapter III, M. C. Birch, Ed., p. 35-61. BEHAVIORAL CHEMICALS, ATTRACTANTS, MORPHOLOGY AND PHYSIOLOGY Pheromone perception in bark beetles is reviewed.

796. **PAYNE T. L.** 1975. Bark beetle olfaction. III. Antennal olfactory responsiveness of *Dendroctonus frontalis* Zimmerman and *D. brevicomis* Le Conte (Coleoptera: Scolytidae) to aggregation pheromones and host tree terpene hydrocarbons. J. Chem. Ecol. 1:233-242. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, MORPHOLOGY AND PHYSIOLOGY Using electroantennograms, no significant differences in threshold concentration for response could be found for either sex of *Dendroctonus frontalis* or *D. brevicomis* when dilutions of *exo*-brevicomin, frontalis, and the host terpene hydrocarbons 3-carene and *alpha*-pinene were used. Antennal olfactory responses to the compounds did not correlate to published data. Results indicate that both frontalis, and *exo*-brevicomin share the same receptors on the antennae of *D. frontalis*, and that terpene hydrocarbons share some but not all of the receptors.

797. **PAYNE T. L.** 1979. Pheromone and host odor perception in bark beetles. *In*, Neurotoxicology of Insecticides and Pheromones, Narahasi, T., Ed. Plenum Publ. Corp. p. 27-57. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL, CHEMICALS, REVIEW, MORPHOLOGY AND PHYSIOLOGY Olfactory perception in bark beetles is discussed, particularly as it relates to bark beetle behavior. Both EAG and single cell techniques were used in elucidating mechanisms of olfactory perception. Organs of perception are described and discussed. Various aspects of perception (transduction, thresholds, antennal olfactory response, pheromone and host odor acceptors, specificity and odor discrimination, and informational coding) are discussed. An understanding of the events occurring at the antennal olfactory sensilla level provides insights which are important in the development of behavioral chemicals for use in pest management.

798. **PAYNE T. L.** 1980a. Chapter 2. Life history and habits. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Tech. Bull. 1631. p. 7-28. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus arizonicus*, *Dendroctonus mexicanus*, *Bostrichus frontalis*). EGG, LARVAE, PUPAE, ADULT, LIFE HISTORY-GENERAL, AGGREGATION, DISTRIBUTION, EMERGENCE, BEHAVIORAL CHEMICALS, ATTRACTANTS, REVIEW, TAXONOMY, MORPHOLOGY AND PHYSIOLOGY, GENETICS, INTEGRATED PEST MANAGEMENT, MAPS Distribution of *Dendroctonus frontalis* infestations are mapped for 1960-1979. Taxonomy of *D. frontalis* is outlined. Zimmermann originally described *D. frontalis*; in 1963, Stephen Wood synonymized *D. arizonicus* and *D. mexicanus* with *D. frontalis*. Rose (1966 unpublished) suggested distinct differences between *D. frontalis* and *D. mexicanus*. In 1974, Vite and others (1974) provided conclusive evidence that *D. frontalis* and *D. mexicanus* were two distinct species. Wood (1974) reinstated *D. mexicanus* as a valid species. The range of *D. frontalis* is mapped, extending down into Nicaragua and Honduras, through Mexico and Arizona across the southern United States. Pine hosts are listed. The life stages of the southern pine beetle are pictured and described; generation times range from 24 to 56 days and are seasonally dependent. Host selection, including initial attacks, seasonal behavior, aggregation, behavioral chemicals, olfactory receptor systems, and behavioral events are summarized. Colonization, including mating, egg laying, reemergence, and instar development are pictured and described.

799. **PAYNE T. L.** 1980b. Southern pine beetle fact sheet number 9. Use of behavioral chemicals for southern pine beetle suppression--a research update. USDA For Serv. Southeast. Area State and Priv. For. For. Bull. SA-FB/P21. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS Behavioral chemicals can be used for spot disruption of the southern pine beetle. Other management implications are discussed.

800. **PAYNE T. L.** 1981. Disruption of southern pine beetle infestations with attractants and inhibitors. *In*, Manage. of Insect Pests with Semiochemicals, E. R. Mitchell, Ed. Plenum Pub. Corp., New York, New York. p. 365-383. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips avulsus*, *Ips calligraphus*. CLERIDAE; *Thanasimus dubius*). BEHAVIORAL CHEMICALS, ATTRACTANTS, HOST SELECTION, CONTROL-GENERAL, REVIEW A discussion and review of studies dealing with southern pine beetle chemical attractants and inhibitors. Two attractant studies indicate the feasibility of using attractants to disrupt spot dynamics to the extent that expansion is slowed or stopped altogether. Inhibition studies were less successful, possibly due to a coincidental burst in beetle activity, inclement weather conditions during testing, and subsequent rise in *Ips* populations.

801. **PAYNE T. L., COSTER J. E., JOHNSON P. C.** 1977. Effects of slow-release formulation of synthetic *endo*- and *exo*-brevicomin on southern pine beetle flight and landing behavior. J. Chem. Ecol. 3:133-141. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, FLIGHT A slow release formulation of the bark beetle pheromones, *endo*- and *exo*-brevicomin, significantly reduced landing of southern pine beetles on host trees. The pheromones were released a 600mg/ha/day.

802. **PAYNE T. L., COSTER J. E., JOHNSON P. C.** 1979. Development and evaluation of synthetic inhibitors for use in southern pine beetle pest management. *In*, Current Topics in For. Entomol. Selected papers from the XVth Internatl. Congr. of Entomol., Wash., D.C., August 1976, W. E. Waters, Ed. USDA For. Serv. Gen. Tech. Rep. WO-8, p. 139-143. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, FLIGHT, CONTROL-CHEMICAL Since *endo*- and *exo*-brevicomin were shown to reduce the attractiveness of frontalure with *alpha*-pinene, field tests were carried out to evaluate the continual presence of *endo*- and *exo*-brevicomin on flight and landing activities of the

southern pine beetle in a natural infestation. A controlled-release formulation of the compounds was also evaluated. Results suggest a future potential in behavioral chemical southern pine beetle control. Additional field tests are recommended.

803. **PAYNE T. L., COSTER J. E., RICHERSON J. V., EDSON L. J., HART E. R.** 1978. Field response of the southern pine beetle to behavioral chemicals. Environ. Entomol. 7:578-582. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-CHEMICAL Field tests were conducted in East Texas to evaluate the influence of seven behavioral chemicals on the flight and landing behavior of the southern pine beetle. The response to *trans*-verbenol, verbenone, *endo*-brevicomin, *exo*-brevicomin, frontalin, *alpha*-pinene, and loblolly turpentines were tested. Trap catch was reduced with high verbenone concentrations. *Endo*-brevicomin inhibited trap catch when added to an attractant-baited trap, *exo*-brevicomin did not.

804. **PAYNE T. L., COSTER J. E., RICHERSON J. V., HART E. R., HEDDEN R. L., EDSON L. J.** 1978. Reducing variation in field tests of behavioral chemicals for the southern pine beetle. J. Ga. Entomol. Soc. 13:85-90 (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, FLIGHT, TRAPS AND CAGES Variation (temporal and spatial) response of the southern pine beetle to attractant-baited traps was studied in several natural infestations. Daily variation was lowest when traps were placed near trees where beetles were predominantly within the first to third instar larvae life stages; highest variation occurred where adult beetles were landing on trees and attacking in mass. A 30% reduction in trap catch variability was noted when trapping periods were reduced from 24 hours to 30 minutes. Suggestions for reducing trapping variation are given.

805. **PAYNE T. L., COULSON R. N., THATCHER R. C.** 1974. Southern pine beetle symposium. For. Insect Res., Tex. Agric. Exp. Stn., College Station, Tex. 57 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW, POPULATION DYNAMICS, ECONOMIC IMPACT A series of papers are presented on southern pine beetle population dynamics, life history, economic impact, and ecological role.

806. **PAYNE T. L., DICKENS J. C.** 1976. Adaptation to determine receptor system specificity in insect olfactory communication. J. Insect Physiol. 22:1569-1572. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, MORPHOLOGY AND PHYSIOLOGY, MISCELLANEOUS TECHNIQUES Electroantennogram and/or single cell recording procedures are used to employ the differential adaptation of antennal olfactory acceptors to elucidate receptor system specificity. From this technique, the extent to which two or more behavioral chemicals interact with the same acceptors can be shown. Insight into the olfactory receptor system of an organism is elucidated. This technique should be valuable for studying several behavioral chemicals for the same insect.

807. **PAYNE T. L., HART E. R., EDSON L. J., MCCARTY F. A., BILLINGS P. M., COSTER J. E.** 1976. Olfactometer for assay of behavioral chemicals for the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). J. Chem. Ecol. 4:411-419. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, MISCELLANEOUS TECHNIQUES An open-arena olfactometer for behavioral chemical assay for use with pedestrian insects has been developed for the southern pine beetle. A description of the device is included, along with preliminary southern pine beetle reaction data. Results show that at low rates, and a standard mixture (frontalin, *trans*-verbenol and loblolly turpentine at a 1:1:12 ratio), only a few beetles give a positive response and at higher levels many give a positive response.

808. **PAYNE T. L., MOECK H. A., WILLSON C. D., COULSON R. N., HUMPHREYS W. J.** 1973. Bark beetle olfaction. II. Antennal morphology of sixteen species of Scolytidae (Coleoptera). Int. J. Insect Morphol. Embryol. 2(3):177-192. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp. *Ips* spp. *Pseudohylesinus* sp., *Scolytus* sp., *Trypodendron* sp.). ADULT, MISCELLANEOUS TECHNIQUES, TAXONOMY, MORPHOLOGY AND PHYSIOLOGY Using a scanning electron microscope (SEM), antennal surveys were made on several species of bark beetles in the genera *Dendroctonus*, *Ips*, *Pseudohylesinus*, *Scolytus* and *Trypodendron*. The majority of sensilla, including sensilla basiconica, sensilla chaetica, and sensilla trichodea occurred on the club in all species. Sensilla occurred in bands or sensory fields on the club. Their possible functions are discussed.

809. **PAYNE T. L., RICHERSON J. V.** 1979. Management implications of inhibitors for *Dendroctonus frontalis* (Col. Scolytidae). Bull. Soc. Entomol. Suisse 52:323-331. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips avulsus*). BEHAVIORAL CHEMICALS, ATTRACTANTS A mixture of *endo*- and *exo*-brevocomin resulted in an 84%reduction in landing, a 92% reduction in gallery construction and an 88% reduction in egg laying. More *Ips avulsus* landed on treated than control trees. Clerids were not affected.

810. **PAYNE T. L., RICHERSON J. V., DICKENS J. C., WEST J. R., MORI K., BERISFORD C. W., HEDDEN R. L., VITÉ J. P., BLUM M. S.** 1982. Southern pine beetle: Olfactory receptor and behavior discrimination of enantiomers of the attractant pheromone frontalin. J. Chem. Ecol. 8:873-881. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS In laboratory and field bioassays, the response of *Dendroctonus frontalis* was significantly greater to the mixture of (15,5R)-(−)-frontalis and *alpha*-pinene than to (1R,55)-(+)-frontalis and *alpha*-pinene.

811. **PAYNE T. L., WOOD D. L.** 1981. Role of behavioral chemicals in integrated pest management in the New World. *In*, Proc. XVII IUFRO World Congr., Kyoto, Japan. p. 475-492. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, SURVEY AND DETECTION Behavioral chemicals generally have two uses in integrated pest management–survey and detection, and suppression and prevention. Survey traps have been employed in management practices for several insect pests. Trap-out and disruption techniques have also met with some success. Behavioral chemicals provide valuable contributions to IPM when combined with sound forest management.

812. **PAZ M. H.** 1975. El gorgojo de la corteza, plaga principal de los pinares, *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae). Corporacion Hondurena de Desarrollo Forestal. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CULTURAL Impact of the southern pine beetle in Honduras is presented.

813. **PERUSQUIA, O. J.** 1978. Descortezador de los pinos (*Dendroctonus* spp.) taxonomia y distribucion. Mex. Sec. Agric. Recurs HIDRAUL., Bol. Tech. 55. 31p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). DISTRIBUTION, TAXONOMY The distribution and taxonomy of *Dendroctonus* spp. are presented.

814. **PHELPS W. R.** 1977. Protect your forests from insects and diseases. For. Farmer 36(5):28-29. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). SURVEY AND DETECTION Discusses insect/disease management in general terms.

815. **PITMAN G. B.** 1969. Bark beetle manipulation with natural and synthetic attractants. *In*, Insect-plant interactions, Natl. Acad. Sci., Washington D. C. p. 56-58. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus ponderosae*, *Dendroctonus brevicomis*, *Dendroctonus jeffreyi*). BEHAVIORAL CHEMICALS, REVIEW Summary of a work conference in March, 1968. Results of research on pheromone chemistry, host-insect interactions in pheromone synthesis, and the use of synthetic attractants in the field are summarized. *Trans*-verbenol is identified as the 'major attractive component' of *Dendroctonus frontalis*.

816. **PITMAN G. B., VITÉ J. P.** 1969. Aggregation behavior of

Dendroctonus ponderosae (Coleoptera: Scolytidae) in response to chemical messengers. Can. Entomol. 101:143-149. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus ponderosae*, *Dendroctonus brevicomis*, *Dendroctonus frontalis*). POPULATION DYNAMICS, AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS The release of insect produced volatiles coinciding with host volatiles in the resin of the attacked tree cause populations of *Dendroctonus ponderosae* to aggregate in large numbers. Synthetic *trans*-verbenol, when tested in conjunction with oleoresin under field conditions, was highly attractive to both sexes of *D. ponderosae*. *D. brevicomis* and *D. frontalis* females (both contain large amounts of *trans*-verbenol) when crushed to a powder at negative 70 degrees Celsius were also found to be highly attractive to *D. ponderosae*. *Trans*-verbenol was not attractive to *D. ponderosae* when the insect was walking or in flight.

817. **PITMAN G. B., VITÉ J. P., KINZER G. W., FENTIMAN A. F. JR.** 1968. Bark beetle attractants: *Trans*-verbenol isolated from *Dendroctonus*. Nature 218(5137):168-169. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus brevicomis*, *Dendroctonus frontalis*, *Dendroctonus ponderosae*). AGGREGATION, ATTRACTANTS *Trans*-verbenol was isolated from *Dendroctonus ponderosae*; methods are given for isolation. The significance of *trans*-verbenol in female hindguts is discussed.

818. **PITMAN G. B., VITÉ J. P., KINZER G. W., FENTIMAN A. F. JR.** 1969. Specificity of population-aggregating pheromones in *Dendroctonus*. J. Insect Physiol. 15:363-366. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, MORPHOLOGY AND PHYSIOLOGY, COMMENSALISM AND SYMBIOSIS Using gas-liquid chromatography, and mass spectrometry of volatile hindgut components of *Dendroctonus*, the presence of *trans*-verbenol and brevicomin can be measured. Using this technique, it was shown that scolytid pheromones are associated with the alimentary system; therefore, small quantities of the pheromone should be found in either sex. It is proposed that olfactory receptor systems are more specific in scolytids, than systems of pheromone production, and that aggregation is largely maintained by this system.

819. **PLUMB G. H.** 1958. Some destructive bark beetles. Sci. Tree Topics 2:8-10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL Brief discussion of the southern pine beetle.

820. **PLUMMER E. L., STEWART T. E., BYRNE K. J., PEARCE G. T., SILVERSTEIN R. M.** 1976. Determination of the enantiomeric composition of several insect pheromone alcohols. J. Chem. Ecol. 2:307-332. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Gnathotrichus sulcatus*, *Scolytus multistriatus*, *Dendroctonus pseudotsugae*, *Ips pini*). BEHAVIORAL CHEMICALS, ATTRACTANTS The enantiomeric composition of bark beetle pheromones are discussed and implications for their use are summarized.

821. **POPE D. N., COULSON R. N., FARGO W. S., GAGNE J. A., KELLY C. W.** 1980. The allocation process and between-tree survival probabilities in *Dendroctonus frontalis* infestations. Res. Popul. Ecol. 22:197-210. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING, POPULATION DYNAMICS The colonization by reemerged and emerged *Dendroctonus frontalis* adults results in a continuous development of infestations. A fused probability transfer function and a time-temperature dependent function were used in the allocation of adults. The average between-tree survival probability was ca. 0.43. The two survival components of reemerging and emerging beetle survival were complimentary to each other. A continuous source population appears very important in the development of an infestation.

822. **PORTERFIELD R. L., ROWELL C. E.** 1981. Characteristics of southern pine beetle infestations southwide. *In*, Site, stand and host characteristics of southern pine beetle infestations, J. E. Coster and J. L. Searcy, Eds. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. 1612, p. 87-108. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FIRE, HAZARD/RISK RATING, INTEGRATED PEST MANAGEMENT, STAND CONDITIONS, LIGHTNING Summarizes southern pine beetle data collection for the Expanded Southern Pine Beetle Research Applications Program (ESPBRAP). In all, 92% of the southern pine beetle plots and 95% of the baseline plots were established in naturally occurring stands. Recent logging activity and lightning strikes predispose stands to southern pine beetle attack. Reducing understory competition by fire may reduce southern pine beetle-hazard. High basal area, larger pines, higher stocking, and change in landform are related to southern pine beetle in the Coastal Plain. In the Piedmont area, infestations occurred on sites with greater slope, higher soil content, and shallower surface soils than the Coastal Plain infestations. Loblolly pine planted 'off site' may be more susceptible to southern pine beetle. In the mountain subregion, lightning strikes and recent logging was associated with southern pine beetle infestations. Also the mountain stands had higher basal areas and slower radial growth in southern pine beetle-infested stands.

823. **PRICE T. S., DOGGETT C., EDS. AND COMPILERS.** 1978. A history of southern pine beetle outbreaks in the southeastern United States. Geo. For. Comm., Macon, Ga. 31 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, REVIEW, IMPACT Damage estimates of southern pine beetle outbreaks in the southeastern United States, 1960-1976, are presented in tabular form and distribution maps of infestations are also presented. Economic losses are estimated by state from 1882-1960.

824. **PRICE T. S., GODBEE J.** 1974. The southern pine beetle in Georgia. Ga. For. Assoc. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp. *Heterobasidion annosum*). LIFE HISTORY-GENERAL, CONTROL-GENERAL, CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION, FIRE, ECONOMICS, IMPACT Describes life history and detection of southern pine beetle. History of southern pine beetle outbreaks in Georgia is summarized as follows: In 1961-1962, 5.5 million board feet of timber and 14,000 cords of pulpwood were salvaged or treated. During 1967, a smaller outbreak was detected. Maps are given for 1971-1974 outbreaks. Suppression programs were started in 1972; the major program was salvage. Two other control measures are operational: chemical treatment with lindane and burning trees felled by landowners. In 1974, southern pine beetle populations were light in southern Georgia and medium to heavy in northern Georgia. A forest pest detection and prevention plan for Georgia is outlined including detection surveys, aerial survey procedures, forms for reporting of sketch map data, ground survey procedures, ground control procedures, and training.

825. **PULLEY P. E., COULSON R. N., FOLTZ J. L.** 1979. Sampling bark beetle populations for abundance. *In*, Contemporary Quantitative Ecol. and Related Ecometrics, G. P. Patil and M. Rosenzweig, Eds. Stat. Ecol. Ser. Vol. 12. Int. Coop. Publ. House, Burtonsville, Md. p. 649-662. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING Procedures for sampling within-tree and within-infested populations of *Dendroctonus frontalis* are presented. The purposeful, rather than the random, selection of samples approach is taken. The procedures should be applicable for population estimates of other bark beetle species.

826. **PULLEY P. E., COULSON R. N., FOLTZ J. L., MARTIN W. C., KELLEY C. L.** 1977. Sampling intensity, informational content of samples, and precision in estimating within-tree populations of *Dendroctonus frontalis*. Environ. Entomol. 6:607-615. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, DISTRIBUTION, STATISTICAL METHODS, MODELING Selective sampling techniques such as the TG-PDF procedure provide better precision than random or stratified sampling. Precision increases with increasing numbers of samples. Optimum placement of sampling levels varies with the life stage being sampled. Usually, two or three levels provide an adequate estimation for most sampling requirements.

827. **PULLEY P. E., COULSON R. N., KELLEY C. L.** 1979. Accuracy and precision of the topological mapping procedure for estimating within-tree populations of bark beetles. Res. Popul. Ecol. 20:201-210. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, STATISTICAL METHODS, MISCELLANEOUS TECHNIQUES The accuracy and precision of the topological mapping procedure for estimating within-tree populations of bark beetles was investigated for a variety of different sampling conditions. Simulation techniques were used to represent infested trees and to perform subsampling. When 25 cm. sampling intervals were used, a linear transition between adjacent observations was observed. The number of samples collected at one height and the vertical spacing between heights were varied.

828. **PULLEY P. E., FOLTZ J. L., COULSON R. N., MARTIN W. C.** 1977. Evaluation of procedures for estimating within-spot populations of attacking adult *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 109:1325-1334. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, POPULATION DYNAMICS, DISTRIBUTION, MODELING The precision, bias and cost of various sampling schemes are presented for within-spot estimates of attacking *Dendroctonus frontalis* density using 100 square cm. disks of bark. The most unbiased estimate was found using random selection of trees to be sampled, while random selection coupled with scaling by the number of infested trees was the least precise procedure. Sampling at two heights (3.5 and 6.5m, 4-100 squared cm disks/height) provided the most precise estimates, but addition of one or two additional trees provided equally precise single height estimates. Emerging adult beetles were the most costly to sample.

829. **PULLEY P. E., FOLTZ J. L., MAYYASI A. M., COULSON R. N.** 1976. Topological mapping to estimate numbers of bark-inhabiting insects. Environ. Entomol. 5:640-643. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MISCELLANEOUS TECHNIQUES, SURVEY AND DETECTION A method to predict per tree beetle populations using a tree contour system for data collection point location is presented. The procedure has two constraints: the contour must pass through all the sample points, and the boundaries of the surface must be pointwise the same as the adjacent boundaries of bordering solids. Data collection involves measuring insect density at intervals on the bole.

830. **PULLEY P. E., FOLTZ J. L., MAYYASI A. M., COULSON R. N., MARTIN W. C.** 1977. Sampling procedures for within-tree attacking adult populations of the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 109:39-48. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MISCELLANEOUS TECHNIQUES Accuracy and precision of five sampling schemes and the effect of various sampling parameters indicate the most precise sample estimates are obtained from sampling the infested bole at frequent intervals.

831. **PURSER G. C.** 1977. Laboratory studies on the developmental biology of *Thanasimus dubius* Fab. (Coleoptera: Cleridae) M. S. Thesis, Miss. State Univ., Miss. State, Miss. 34 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). EGG, LARVAE, PUPAE, ADULT, PREDATOR, POPULATION DYNAMICS Developmental rates of *T. dubius* increased with temperature.

832. **RAGENOVICH I.** 1973. Impact of some carbamate and phosphate insecticides on *Dendroctonus frontalis* Zimmerman and *Ips* engraver beetles. M. F. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 39 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp.). CONTROL-CHEMICAL Lindane provided significant control of established southern pine beetle broods. Imidan, diazinon and Sevin caused high mortality of emerging adult beetles. Lindane, Baygon and Sevin were effective in preventing *Ips grandicollis* and *I. calligraphus* attacks on loblolly pine logs.

833. **RAGENOVICH I.** 1980. Effects of subzero Fahrenheit temperatures on southern pine beetle populations in the southern Appalachians. South. J. Appl. For. 4:201-203. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, WEATHER RELATIONSHIPS Low winter temperatures in the southern Appalachians resulted in 95% brood mortality. Other factors leading to increased mortality include egg and larval stages in moist phloem, thinner host tree bark, and the portion of the bark occupied by the brood.

834. **RAGENOVICH I. R., COSTER J. E.** 1974. Evaluation of some carbamate and phosphate insecticides against southern pine beetle and *Ips* bark beetles. J. Econ. Entomol. 67:763-765. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp.). LARVAE, ADULT, CONTROL-GENERAL, CONTROL-CHEMICAL Lindane significantly reduced established southern pine beetle broods. Phosmet caused high mortality of adult beetles in 24 hours after emergence from treated pines. Lindane, propoxur and carbaryl were effective in preventing *Ips grandicollis* and *I. calligraphus* attacks on loblolly pine logs. Acephate, phosmet and diazinon were not as effective in reducing populations.

835. **REAMER L. D.** 1964. The incidence of southern pine beetle in stands of varying densities. Proc. 43rd Meeting Appalachian Sec. Soc. Am. For. p. 17-18. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The southern pine beetle was most prevalent in dense, overmature pine stands.

836. **REED D. D.** 1979. Estimating region-wide damages caused by the southern pine beetle. M.S. Thesis, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 90 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT, MODELING, ECONOMICS A model is described which estimates the number of southern pine beetle infestations likely to occur in a region during the course of a year. This spot incidence model predicts the probability that an infestation will occur in a stand of given characteristics. Another model produces a method for simulating the growth of an individual infestation, this provides a prediction of the eventual size of each infestation. The combination of the two models produce a region-wide southern pine beetle impact projection system (DAMBUGS).

837. **REED D. D., BURKHART H. E., LEUSCHNER W. A.** 1979. Simulating the spread of southern pine beetle infestations. Va. J. Sci. 30:35. (Abst.) (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, MODELING The predicted growth of southern pine beetle spots is simulated.

838. **REED D. D., BURKHART H. E., LEUSCHNER W. A.** 1980. Long-term, regional projections of southern pine beetle damages. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 152-156. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING The Timber Resource Analysis System (TRAS) is a model developed by the USDA Forest Service to project long-term timber supply considering removal rates and management practices. This program classifies site and stand characteristics, applying them to calculate the net change per year in the number of trees in each two-inch diameter class. Mortality rates are provided by the user with no provision for distinguishing the causes of mortality. Methods presented here incorporate into TRAS the amount of tree mortality due to the southern pine beetle. This is achieved by estimating the number of spots likely to occur (using site and stand variables) and the growth of each spot per year. These estimations include consideration of natural and artificial termination of spot activity.

839. **REED D. D., BURKHART H. E., LEUSCHNER W. A., HEDDEN R. L.** 1981. A severity model for southern pine beetle infestations. For. Sci. 27:290-296. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING The development of a model which simulates the spread of southern pine beetle infestations by using stand level variables is described. The use of two functions (to predict the rate of spread and to predict the probability of a spot becoming inactive) used to simulate spot growth is

presented. The model performs well in predicting overall physical damage, but does not do too well in estimating damage for individual infestations.

840. **REED D. D., DANIELS R. F., HEDDEN R. L., BURKHART H. E., LEUSCHNER W. A.** 1980. A regional southern pine beetle damage projection system. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980, Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 132-144. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING Models were developed to simulate southern pine beetle activity and project the expected damages in terms of cubic feet of timber destroyed given the forest conditions of the region. Because the variables involved in spot initiation and spot spread may differ, two models were developed and combined to form a regional damage protection system. This system was demonstrated on an example region in the Georgia Piedmont.

841. **REED D. D., HEDDEN R. L., DANIELS R. F.** 1982. Estimating the annual probability of southern pine beetle outbreak. For. Sci. 28:202-206. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, POPULATION DYNAMICS Logistic regression equations to predict southern pine beetle attack probability are modified to represent years other than the times the model was developed.

842. **REEVE R. J.** 1979. Temporal and spatial distributions of flying *Dendroctonus frontalis* Zimmerman (Coleoptera: Scolytidae) and the predator *Thanasimus dubius* F. (Coleoptera: Cleridae) in and near small infestations. M. S. For. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 72 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). FLIGHT, DISTRIBUTION, PREDATOR The southern pine beetle and its predator, *T. dubius*, were examined over space and time in an infestation in East Texas.

843. **REEVE R. J., COSTER J. E., JOHNSON P. C.** 1980. Spatial distribution of flying southern pine beetle (Coleoptera: Scolytidae) and the predator *Thanasimus dubius* (Coleoptera: Cleridae). Environ. Entomol. 9:113-118. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, PARASITES, POPULATION DYNAMICS, AGGREGATION, TRAPS AND CAGES A comparison of distribution of flying southern pine beetle and its clerid predator, *Thanasimus dubius*, in three infestations indicated a positive correlation between the degree of aggregation of the two species although there was an inverse relationship with regard to population density. Lloyd's index of interspecific patchiness indicated overlapping, aggregate distributions, presumably due to a kairomonal response of *T. dubius* to southern pine beetle behavioral chemicals.

844. **RENWICK J. A. A.** 1967. Identification of two oxygenated terpenes from the bark beetles *Dendroctonus frontalis* and *Dendroctonus* brevicomis. Contrib. Boyce Thompson Inst. Plant Res. 23(10):355-360. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, MISCELLANEOUS TECHNIQUES Verbenone from *Dendroctonus frontalis* and *D. brevicomis* males, and *trans*-verbenol from *D. frontalis* and *D. brevicomis* females, were identified using infrared, NMR, and mass spectrometry.

845. **RENWICK J. A. A.** 1970a. Chemical aspects of bark beetle aggregation. Contrib. Boyce Thompson Inst. 24:337-341. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Ips* spp.). AGGREGATION, BEHAVIORAL CHEMICALS, HOST SELECTION The first step in identification of a behavioral chemical is the determination of the source using bioassay. Initial analysis of the attractive material requires very small samples which are run through a gas chromatograph and mass spectrophotometer to determine the molecular weight and clues about structure. The infrared spectrum, which requires larger samples, can reveal the presence of functional groups and particular types of bonding. NMR spectroscopy elucidates the geometrical arrangement of atoms in a molecule. The final step is the synthesis of the compound. Bark beetle attractants can be classified as bicyclic ketals or terpene alcohols. The pheromone structure is critical to species-specific response, although host terpenes that supplement attraction are somewhat inter changeable. Species of *Dendroctonus* can be classified according to their response to particular pheromones and terpenes.

846. **RENWICK J. A. A.** 1970b. *Dendroctonus frontalis* - Die Steuerung des Befalls neuer Wirtsbaume durch Geruchsstoffe. Diss., GeorgAugust. Univ. zu Gottingen In Hann, Munden. 83 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, MISCELLANEOUS TECHNIQUES Distillation, gas chromatography, and spectrometry were used to analyze the chemical constituents of the southern pine beetle and its host, *Pinus taeda*. The role of isolated compounds in the phenomenon of mass aggregation was studied.

847. **RENWICK J. A. A.** 1972. The chemistry of *Dendroctonus frontalis* aggregation. Folia. Entomol. Mex. 24:85. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS Four chemical compounds have been identified which are used in the complex pheromone system of the southern pine beetle. These compounds are used to mark a specific tree for mass attack, to regulate their population density, and to trigger the switching of attack to neighboring trees.

848. **RENWICK J. A. A., HUGHES P. R.** 1975. Oxidation of unsaturated cyclic hydrocarbons by *Dendroctonus frontalis*. Insect Biochem. 5:459-463. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MORPHOLOGY AND PHYSIOLOGY Adult *D. frontalis* were held in Petri dishes and exposed for 20 hours to 1-methyl-1-cyclohexene. Exposure resulted in production of seudenal (3-methyl-2-cyclohexen-1-ol), a pheromone of *D. pseudotsugae*, along with the corresponding ketone and other alcohols. The most abundant alcohol was 1-cyclohexenemethanol. A rearrangement product of seudenal, also believed to be present in *D. pseudotsugae* hindguts, was identified as 1-methyl-2-cyclohexen-1-ol. Upon exposure to *alpha*-pinene, *D. frontalis* females produced *cis*- and *trans*-verbenol as well as *cis*-3-pinin-2-ol. Renwick found that *D. frontalis* females can oxidize *beta*-pinene to *trans*-pinocarveal and myrtenol. These findings suggest that there is a general mechanism of oxidation and rearrangement of toxic host terpenes and alcohols by *D. frontalis*.

849. **RENWICK J. A. A., HUGHES P. R., PITMAN G. B., VITÉ J. P.** 1976. Oxidation products of terpenes identified from *Dendroctonus* and *Ips* bark beetles. J. Insect Physiol. 22:725-727. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Ips paraconfusus*). BEHAVIORAL CHEMICALS Exposure of adult males and females of *Dendroctonus brevicomis* and *D. frontalis* to camphene vapors resulted in the oxidation of the terpene to camphenol (6-hydroxy-camphene). Other oxidation compounds are included for myrcene vapor (to myrcenol and ipsdienol).

850. **RENWICK J. A. A., HUGHES P. R., TY T. D.** 1973. Oxidation products of pinene in the bark beetle, *Dendroctonus frontalis*. J. Insect Physiol. 19:1735-1740. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, BEHAVIORAL CHEMICALS, ATTRACTANTS *Dendroctonus frontalis* collected from beetle-infested pines and exposed to *alpha*- and *beta*-pinene for 20 hours in Petri dishes showed changes in the volatile contents of their hindguts. Males produced *cis*- and *trans*-verbenol after exposure to *alpha*-pinene; 4-methyl-2-pentanol was found in both sexes. Myrtenol was found in both sexes before and after treatment; a less conspicuous male-specific compound, myrtenol was identified. After *beta*-pinene, *trans*-pinocarveol was identified in both sexes, and pinocarvone was identified in the males. The role many of the oxygenated terpenes play as pheromones for the aggregation of bark beetles is not known yet.

851. **RENWICK J. A. A., HUGHES P. R., VITÉ J. P.** 1975. The aggregation pheromone system of a *Dendroctonus* bark beetle in Guatemala. J. Insect Physiol. 21:1097-1100. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus vitei*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, MORPHOLOGY AND

PHYSIOLOGY Bioassay results of the volatile contents of hindguts of *Dendroctonus vitei* in Guatemala showed distinct differences when compared to the morphologically similar *D. frontalis*. Results suggest that frontalin is the key compound responsible for the aggregation of the Guatemalan species, but response-regulating mechanisms differ from that of *D. frontalis*. Other *D. vitei* compounds produced included 1-phenylethanol (emergent males), 1- and 2-heptanol (both sexes), myrtenol (in males only) and frontalin and *trans*-verbenol by attacking females.

852. **RENWICK J. A. A., VITÉ J. P.** 1968. Isolation of the population aggregating pheromone of the southern pine beetle. Contrib. Boyce Thompson Inst. 24:65-68. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Dendroctonus pseudotsugae*). POPULATION DYNAMICS, AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, FLIGHT, MISCELLANEOUS TECHNIQUES A population aggregating pheromone of *Dendroctonus frontalis* was isolated from the hindguts of male and female beetles.

853. **RENWICK J. A. A., VITÉ J. P.** 1969. Bark beetle attractants: Mechanism of colonization by *Dendroctonus frontalis*. Nature 224:1222-1223. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-CHEMICAL Renwick and Vite define the attack mechanism of *Dendroctonus frontalis*. The major terpene component of *Pinus taeda*, *P. palustris*, *P. elliottii*, and *P. echinata* was *alpha*-pinene and other compounds. The attack sequence was outlined as follows: 1) initial attack by females with the release of frontalin and the host terpene *alpha*-pinene attacking beetles; 2) regulation of sex ratio by verbenone, frontalin and *alpha*-pinene; and 3) termination of attack and shifting to a new host induced by the pheromone verbenone.

854. **RENWICK J. A. A., VITÉ J. P.** 1970. Systems of chemical communication in *Dendroctonus*. Contrib. Boyce Thompson Inst. 24:283-292. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Dendroctonus ponderosae*). AGGREGATION, BEHAVIORAL CHEMICALS, HOST SELECTION The mechanisms of mass aggregation and colonization of healthy trees by *Dendroctonus frontalis*, *D. brevicomis* and *D. ponderosae* were investigated. Synthetic samples of previously identified pheromones were tested in the field to determine their respective roles. *Trans*-verbenol, produced by females of all three species, serves as the aggregation pheromone for *D. ponderosae*, supplements *D. frontalis* attraction, but has no apparent effect on *D. brevicomis*. Frontalin is a key aggregating pheromone of *D. brevicomis* and *D. frontalis*. Verbenone, found in males of these two species, balances the sex ratio of *D. frontalis* responding to frontalin by inhibiting males in low concentrations, but in high concentration inhibits the response of both sexes, more markedly for *D. brevicomis*. *D. brevicomis* females produce brevicomin, which attracts males predominantly. Volatile components of host tree resin are essential synergists for mass attraction by pheromones. *Alpha*-pinene is the most effective host compound for increasing the attraction of *D. frontalis* and *D. brevicomis*. Terpenes such as 3-carene or myrcene supplement pheromone attractiveness for *D. brevicomis*. Mechanisms are proposed by which these beetles use chemical cues to select a host, effect mass attack, regulate sex ratios and prevent overpopulation on a host.

855. **RICHERSON B. A.** 1978. Coordinated research to control the southern pine beetle. Tex. Agric. Prog. Spring. p. 4-6. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, POPULATION DYNAMICS, BEHAVIORAL CHEMICALS, SURVEY AND DETECTION, MODELING, REVIEW Summarizes Texas A&M research efforts for the Expanded Southern Pine Beetle Research and Applications Program (ESPBRAP) supported by the USDA Forest Service and Cooperative States Research Service. Projects investigated include beetle biology, attack behavior, mathematical models, population dynamics, and behavioral chemicals.

856. **RICHERSON J. V., MCCARTY F. A., PAYNE T. L.** 1980. Disruption of southern pine beetle infestations with frontalure. Environ. Entomol. 9:90-93. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). BEHAVIORAL CHEMICALS, ATTRACTANTS, PREDATOR Frontalure contained emerging broods of *Dendroctonus frontalis* within active infestations when host and non-host trees were baited. The predator, *Thanasimus dubius*, was also redistributed within the infestations. New trees were not mass-attacked and adult beetles were contained within the infestation.

857. **RICHERSON J. V., PAYNE T. L.** 1979. Effects of bark beetle inhibitors on landing and attack behavior of the southern pine beetle and beetle associates. Environ. Entomol. 8:360-364. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp., *Thanasimus* spp.). BEHAVIORAL CHEMICALS, ATTRACTANTS, FLIGHT Four combinations of southern pine beetle behavioral chemicals (*endo*- and *exo*-brevicomin, 50:50; *endo*- and *exo*-brevicomin, 85:15; *endo*- and *exo*-brevicomin + verbenone, 25:25:50; and verbenone) were tested for landing trap catch reduction, rate of attack of new trees and gallery length. The two brevicomin treatments (combining data from three tests) reduced landing trap catch by 74 percent compared to a 84 percent reduction for brevicomins + verbenone (both significant at $P < 0.05$). No significant changes in new trees attacked or gallery length were found.

858. **RICHERSON J. V., PAYNE T. L.** 1980. Management implications of attractants for *Dendroctonus frontalis*. *In*, Proc. Second IUFRO Conf. on Dispersal of For. Insects: Evaluation, Theory and Manage. Implications, Sandpoint., Idaho, Aug. 1979, Berryman A. A., Safranyik L., Eds. p. 164-172. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS, BEHAVIORAL CHEMICALS, CONTROL-CHEMICAL Behavioral chemicals can be used to manipulate southern pine beetle populations.

859. **RICHMOND J. A., DEMILO A. B., THOMAS H. A., BORKOVEC A. B.** 1978. Mortality and sterility of southern pine beetles treated with chemosterilants and growth regulators. J. Ga. Entomol. Soc. 13:237-240. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, FECUNDITY, BEHAVIORAL CHEMICALS, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL, MORPHOLOGY AND PHYSIOLOGY Male and female *Dendroctonus frontalis* were sterilized by topical applications of the chemosterilants tepa, thio-tepa, bisazir, or hempa. Two insect growth inhibitors, diflubenzuron and penfluron, sterilized females better than males. Effects of dosage on reproduction were highest with thio-tepa and bisazir, followed by tepa, diflubenzuron, and penfluron. Two types of sterilizing effects were observed: a decrease in egg hatching, and a decrease in oviposition.

860. **RIESENMAN M. F.** 1977. An analysis of the southern pine beetle's impact on aesthetic values of forested landscapes. M.S. Thesis, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 142 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AESTHETICS, IMPACT The extent of aesthetic losses from southern pine beetle damage was investigated and an attempt was made to qualitatively assess the possible reasons for losses. A paired comparison routine was used to determine landscape preferences of subjects with varying degrees of forestry expertise. Experimental subjects disliked landscapes containing black and orange-brown damage, while control subjects preferred landscapes containing orange-brown damage.

861. **ROBERTS E. A., BILLINGS P. M., PAYNE T. L., RICHERSON J. V., BERISFORD C. W., HEDDEN R. L., EDSON L. J.** 1982. Seasonal variation in laboratory response to behavioral chemicals of the southern pine beetle. J. Chem. Ecol. 8:641-652. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS A new laboratory for southern pine beetle research is announced. Pheromone attraction and host selection are discussed at length.

862. **ROBERTSON R. L., WHITEFIELD F.** 1975. Southern pine beetle in North Carolina. N. C. Agric. Ext. Serv. Ext. Folder 274 (Rev.). (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). LIFE HISTORY-

GENERAL, CONTROL-GENERAL, CONTROL-CHEMICAL Briefly summarizes life history and control of the southern pine beetle; applications for lindane and BHC are given.

863. **ROBINSON J. V.** 1981. Pine bark beetles. Tex. Agric. Ext. Serv., Tex. A&M Univ., L-921. 4 p. (COLEOPTERA; SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). LIFE HISTORY-GENERAL, CONTROL-CHEMICAL Summarizes the life history and control of the southern pine beetle.

864. **RODRIGUEZ L. R.** 1966. Direct control of *Dendroctonus frontalis* Zimm. by destroying, debarking and burning infested trees. Bosques 3:8-11. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL Cultural controls for *Dendroctonus frontalis* are summarized.

865. **ROSE W. E.** 1966a. The biology and ecology of *Dendroctonus valens*, and the biology, ecology, and control of *Dendroctonus frontalis* in Central Mexico. Ph.D. Diss., Univ. Mass. 243 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus valens*). LIFE HISTORY-GENERAL, ECOLOGICAL DISTRIBUTION, CONTROL-GENERAL The biology of the southern pine beetle is presented for Central Mexico.

866. **ROSE W. E.** 1966b. Control quimico del descortezador del pino *Dendroctonus frontalis* (=*mexicanus*) Zimm. en Mexico Central (Coleoptera: Scolytidae). (Chemical control of the pine bark beetle *Dendroctonus frontalis* (=*mexicanus*) Zimm. in Central Mexico (Coleoptera: Scolytidae). Rev. Peru. Entomol. 9:10-15. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis* (=*mexicanus*). CONTROL-GENERAL, CONTROL-CHEMICAL Four insecticides (BHC, Malathion, Carbaryl, and EDB) were tested at different concentrations, in the laboratory and field, against *Dendroctonus frontalis*. BHC and Malathion were the most toxic of the four insecticides tested.

867. **ROSE-CHAFFIN W. E.** 1967. Pruebas sobre el control quimico en el laboratorio y en el campo contra el descortezador *Dendroctonus frontalis* (=*mexicanus*) Zimm. (Coleoptera: Scolytidae) en Mexico Central. (Laboratory and field chemical tests for the control of the bark beetle *Dendroctonus frontalis* (=*mexicanus*) Zimm. (Coleoptera: Scolytidae), in Central Mexico). Agrociencia 1(2):53-63. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis* (=*mexicanus*). LARVAE, ADULT, CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL Four insecticides (BHC, Malathion, Sevin, and EDB) were tested at different concentrations in the laboratory and field against *Dendroctonus frontalis*. BHC and Malathion proved highly toxic to *D. frontalis*, and were more toxic to adults than to larvae.

868. **ROSE W. F., BILLINGS R. F., VITÉ J. P.** 1981. Southern pine bark beetles: Evaluation of non-sticky pheromone trap designs for survey and research. Southwest. Entomol. 6(1):1-9. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*. CLERIDAE; *Thanasimus dubius*). BEHAVIORAL CHEMICALS, HOST SELECTION, TRAPS AND CAGES Several types of pheromone-baited traps were compared for practicality and efficiency in attracting and capturing southern pine beetle. Non-sticky flight barriers were superior to perforated cylinders. However, the combination of a perforated cylinder with a flight barrier captured the largest number of bark beetles.

869. **ROSS W. A., MATTOON W. R.** 1939. Farm Forestry. Timber farming including woods management and forest tree planting. U. S. Dep. Inter. Off. Educ. Voc. Div. Bull. No. 196. 63 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). LIFE HISTORY-GENERAL, PREDATOR, VERTEBRATES, CONTROL-CULTURAL, SURVEY AND DETECTION Describes life history and general control tactics for the southern pine beetle. Controls outlined include removing weakened trees and destroying beetle brood coupled with proper survey and detection. Notes on *Ips* and black turpentine beetle are included.

870. **ROTON L. M.** 1978. Mites phoretic on the southern pine beetle: When and where they attach. Can. Entomol. 110:557-558. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. ACARINA). PUPAE, PREDATOR, PARASITES, EMERGENCE, MITES Ten loblolly pine trees naturally infested with *Dendroctonus frontalis* were cut from heights of 4.5 to 9 m. into 1 m. bolt samples. Bark was removed from these samples and 50 beetles each in the pupal, callow-adult, and adult stages were examined for phoretic mites.

871. **ROWELL C. E.** 1978. Describing and predicting the susceptibility of Gulf Coastal Plain stands associated with southern pine beetle. M.S. Thesis, Miss. State Univ., Miss. State, Miss. 115 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, SURVEY AND DETECTION, HAZARD/RISK RATING, STAND CONDITIONS Site and stand variables are evaluated for infested and uninfested plots in the Gulf Coastal Plain. Discriminant analysis and one way analysis of variance is done for the overall Gulf Coastal Plain and by associated landforms. Two models are developed which can correctly classify stands as to infested status 75% of the time. Differentiating variables are total pine cubic foot volume, basal area, slope, ten-year radial growth, and bark thickness.

872. **RUDINSKY J. A.** 1962. Ecology of Scolytidae. Annu. Rev. Entomol. 7:327-348. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW Two major groupings of the family Scolytidae are the ambrosia beetles, which feed on fungus in the woody tissue of the host, and the bark beetles, which feed on the phloem. Each species exhibit a distinct preference for trees or parts of trees with certain physical and physiological characteristics. This preference can change with an increase in beetle population accompanied by a depletion of preferred host material. These conditions can result in a secondary pest reaching primary pest status as in mass outbreaks of *Ips typographus* populations on healthy trees. Bark beetles locate their hosts by responding to odors from the host itself, fermentation, yeast, and/or other beetles. The most important factor in host resistance is resin pressure. Limiting factors of scolytid population growth include availability of suitable host material, high temperatures (42-50 degrees Celsius) in the host, and sufficient rainfall, which contributes to moisture content and resin pressure of the host. Parasites and predators contribute greatly to beetle mortality, but their effects do not prevent build-up of outbreak populations, when host material is readily available. Factors favoring the growth of bark beetle populations are those which weaken trees such as high temperature, drought, snow and ice damage.

873. **RUDINSKY J. A.** 1973. Multiple functions of the southern pine beetle pheromone verbenone. Environ. Entomol. 2:511-514. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, POPULATION DYNAMICS, BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-GENERAL, CONTROL-BIOLOGICAL In laboratory arrestment tests, high concentrations of the pheromone verbenone inhibits male *Dendroctonus frontalis* responses. Low concentrations elicited significantly more male arrestant when mixed with attractants. Male stridulation chirps also differed, low verbenone concentrations produced an 'attractant' chirp, and medium concentrations produced a 'rivalry' chirp characteristic of male fighting. Since females produce small quantities and males produce large quantities of verbenone, these different effects are related to sexual behavior.

874. **RUDINSKY J. A., MICHAEL R. R.** 1974. Sound production in Scolytidae: 'Rivalry' behaviour of male *Dendroctonus* beetles. J. Insect Physiol. 20:1219-1230.(COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, MISCELLANEOUS TECHNIQUES Comparison of stridulation chirps by male *Dendroctonus frontalis* evoked by natural and synthetic chemostimulents confirmed that myrtenol is part of the female attractant, that verbenone functions are dependent on its concentration, and that *endo*-brevicomin has a rivalry function as well as an anti-aggregative effect. Oscillograms of typical acoustical chirps are pictured in the article.

875. **RUDINSKY J. A., MORGAN M. E., LIBBEY L. M., PUTNAM T. B.** 1974. Antiaggregative-rivalry pheromone of the mountain pine beetle and a new arrestant of the southern

pine beetle. Environ. Entomol. 3:90-98. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus ponderosae*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL Pheromones were collected as volatiles from adult *Dendroctonus frontalis* and *D. brevicomis*. Four components for *D. frontalis* confirmed by mass spectrometry (i.e. frontalin, *endo*-brevicomin, *trans*-verbenol and verbenone) were previously found in the hindgut of the sex in this study. In addition, males released frontalin, but not *trans*-verbenol. The terpene alcohol myrtenol, collected from both males and females, and the monoterpene ketone pinocarvone, identified from males and pairs, had not been previously reported. Myrtenol synergized the attractants frontalin and *trans*-verbenol. The attractant chirp occurred consistently. Myrtenol and verbenone are multifunctional pheromones since a small quantity (released by males) was repressive and/or evoked 'rivalry' behavior. The latter were termed antiaggregative 'rivalry' pheromones. The possibility of using these pheromones in control programs is discussed.

876. **RUMBOLD C. T.** 1929. Blue-staining fungi found in the United States. Phytopathology 19:597-599. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). PATHOGENS General summary of blue-staining fungi indicates association with bark beetles.

877. **RUMBOLD C. T.** 1931. Two blue-staining fungi associated with bark-beetle infestation of pines. J. Agric. Res. 43:847-873. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus brevicomis, Ips calligraphus, Ips grandicollis. Ceratostomella pini, Cerastomella ips*). REVIEW, COMMENSALISM AND SYMBIOSIS A blue-stain fungus from galleries of *Dendroctonus frontalis* in southern pine and *D. brevicomis* in western pine was identified in culture as *Ceratostomella pini*. Morphological characteristics of *C. pini* include its black sclerotia and perithecia giving a black and granulated appearance to the phloem of its host trees. The associated stain grows towards the heartwood; the stained wood is gray and the rays and resin ducts appear black. Brown hyphae of *C. pini* grow first into the parenchyma cells of the wood rays, then into the adjoining tracheids. The blue-stain fungus associated with *Ips calligraphus* and *I. grandicollis* is *C. ips*. Rumbold describes laboratory cultures and infested trees in detail.

878. **RUMBOLD C. T.** 1932. Some blue staining fungi associated with several species of bark-boring beetles. Ecol. Soc. Am. Bull. 13(4):17. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus brevicomis, Dendroctonus pseudotsugae, Ips avulsus, Ips calligraphus, Ips grandicollis*). PATHOGENS, COMMENSALISM AND SYMBIOSIS The blue stain fungus, *Ceratostomella pini*, was found in galleries of *Dendroctonus frontalis*.

879. **RUSH P. A., KNAUER K. H.** 1975. Forest management - key to pest control. For. Farmer 39(5):112-113. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). Silvicultural manipulation to prevent southern pine beetle outbreaks is discussed.

880. **RUTHERFORD J. H.** 1978. Evaluation of beetle-killed southern pine from Texas as raw material for pulp and paper. M.S. Thesis, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 73 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Sixty-two trees in the study were grouped into nine classes according to the length of time since death of the tree. Chips from each tree were individually pulped, yields determined, and handsheets prepared and tested for tear, bulk, and breaking length. Little difference was found in paper properties of trees left standing and from those of controls. Standing trees, up to one year after death, may be utilized with little overall influence on chip characteristics.

881. **RYAN G. W., CAROTHERS W. A., MOORE G. E., BHATTACHARYYA H. T.** 1980. Attack:emergence ratio as an indicator of area southern pine beetle population trends and expected timber mortality in the Piedmont of Georgia. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 164-168. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING Population trends will be predicted from attack:emergence ratios and evaluated by using photography and ground sampling.

882. **SADER S. A.** 1976. Development of a risk rating system for southern pine beetle infestations in Copiah County, Mississippi. M. S. For. Thesis, Miss. State Univ., Miss. State, Miss. 61 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS A risk rating system was developed based on four forest stand and topographic variables which can be as certained from color infrared imagery. Forty-two infestations within a sample area were mapped on delineated base map, appear to be most applicable in infestation areas where five or more trees are under attack.

883. **SADER S. A., MILLER W. F.** 1976. Development of a risk rating system for southern pine beetle infestation in Copiah County, Mississippi. *In*, Proc. Remote Sensing of Earth Resources, F. Shamrohki, Ed., Univ. Tennessee, Talahoma, Tenn. 5:277-294. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HAZARD/RISK RATING, STAND CONDITIONS See Sader (1976).

884. **SAND N. H., BRYAN M. M.** 1948 (rev.). Managing the small forest. USDA Farmers' Bull. No. 1989. p. 27-30. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). LIFE HISTORY-GENERAL A brief life history of the southern pine beetle is given.

885. **SCHAUFUSS C. F.** 1892. Bark-beetle destroyer. Can. Entomol. 24:316. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus formicarius*). PREDATOR, CONTROL-BIOLOGICAL Larvae and pupae of *Clerus formicarius* were secured in Germany with the intention of introducing the species into southern pine beetle infestations in West Virginia.

886. **SCHMITT J. J.** 1980. The biology, life history and description of immatures of *Scoloposcelis mississippensis* Drake and Harris and *Lyctocoris elongatus* (Reuter), predators of pine bark beetles. M.S. Thesis, La. State Univ., Baton Rouge, La. 67 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, LIFE HISTORY-GENERAL, FECUNDITY Two anthocorids, *Scoloposcelis mississippensis* and *Lyctocoris elongatus*, are known to be predacious on pine bark beetles. This study presents specific information on the life cycle and behavior of each predator under laboratory conditions, number and duration of developmental stages, prey consumption rates of each life stage, fecundity rates, and descriptions and measurements of each developmental stage.

887. **SCHOENE W. J.** 1926. Fifteenth report of the state entomologist and plant pathologist. Va. State Crop Pest Comm. Q. Bull. 7(4):23. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The southern pine beetle was reported in Virginia in 1923.

888. **SCHOFER G. A., LANIER G. N.** 1970. A sexual character in pupae of *Dendroctonus* (Coleoptera: Scolytidae). Can. Entomol. 102:1487-1488. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). LARVAE, MISCELLANEOUS TECHNIQUES, TAXONOMY, PUPAE A method for sexing the pupae of *Dendroctonus* beetles is discussed. Pupae are sexed by the presence or absence of a protruding lobe occurring between the eighth sternite and the ninth tergite.

889. **SCHOWALTER T. D.** 1981. Insect herbivore relationship to the state of the host plant: Biotic regulation of ecosystem nutrient cycling through ecological succession. Oikos 37:126-130. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). HOST SELECTION, HOST RESISTANCE A discussion of the nature and consequences of insect-plant interactions at the ecosystem level is presented. A knowledge of the mechanisms controlling the self-management of ecosystems may eventually contribute to management practices which imitate natural regulatory systems without disrupting

ecosystem dynamics.

890. **SCHOWALTER T. D., COULSON R. N., CROSSLEY D. A. JR.** 1981. Role of southern pine beetle and fire in maintenance of structure and function of the southeastern coniferous forest. Environ. Entomol. 10:821-825. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FIRE, ECOLOGICAL DISTRIBUTION, A hypothesis is proposed that southern pine forests, the southern pine beetle, and fire interacted historically in the Coastal Plain Region to shape the structure and function of the coniferous forest. The southern pine beetle acts on the system by thinning old or stressed stands, providing concentrations of fuel to enhance the effect of fire, and opening the canopy to enhance the effect of wind. The interactions of fire and the southern pine beetle may have been responsible for a higher community diversity and productivity, reduced nutrient losses, and faster response to disturbance.

891. **SCHOWALTER T. D., POPE D. N., COULSON R. N., FARGO W. S.** 1981. Patterns of southern pine beetle (*Dendroctonus frontalis* Zimm.) infestation enlargement. For. Sci. 27:837-849. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, FLIGHT, SAMPLING Population dynamics of the southern pine beetle as related to forest spatial structure are presented. Eight infestations were examined. Three infestations with large initial populations, grew about 0.9 meters arc distance traversed per day and had 0.4 trees attacked per day. Potential interactions between pheromone dispersion and microclimatic conditions in the forest are discussed. Flight distances for southern pine beetle averaged eight meters for reemerged beetles and 18 meters for emerged beetles. Direction of spread was largely determined by the direction to the nearest unattacked trees relative to trees under attack.

892. **SCHREUDER H. T., CLERKE W. H., BARRY P. J., HOLLAND D. M.** 1980. Two-stage stratified sampling with regression to assess southern pine beetle damage. USDA South. For. Exp. Stn. For. Serv. Res. Pap. SE-212, Asheville, N. C. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION A field test of two-stage stratified sampling with double sampling at the second stage is described. First-stage stratification was based on timber type and sketch maps; second-stage sampling was based on sketch mapping and aerial photo estimates of spot sizes. Based on field test data, recommendations are that heavily infested strata be 100% photographed and lightly infested strata either be sketch-mapped or photographed. Highly trained interpreters with good equipment should be used.

893. **SCHROEDER W. J.** 1965a. Personal interview with a southern pine bark beetle. Va. For. 20(2):18-20,22. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, SURVEY AND DETECTION, IMPACT Impact of the southern pine beetle is discussed for Virginia. Data on the 1964-1965 outbreak is presented.

894. **SCHROEDER W. J.** 1965b. Southern pine bark beetle. Va. Forests 20(2):18-20,22. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL The life history and impact of the southern pine beetle are summarized.

895. **SEAL W. L.** 1964. Highlights of insects conditions in the United States in 1963. FAO Plant Prot. Bull. 12:25-36. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*). SURVEY AND DETECTION A general decline in southern pine beetle populations in the South and Southeast were noted in 1963. Serious epidemics still persist but populations seem to be waning. No serious outbreaks are expected in 1964.

896. **SHAMOUN S. F.** 1978. A chemical and microscopic study of springwood and summerwood of beetle-killed loblolly pine. M. S. Thesis, N. C. State Univ., Raleigh, N. C. 43 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Chemical and microscopic properties of beetle-killed wood differ from that of healthy, live loblolly pines.

897. **SHORE D. G.** 1978. The effects of southern pine beetle (*Dendroctonus frontalis* Zimm.) epidemics on forest watershed dynamics: Will benefits justify control? M.S. Thesis, Va. Polytech. Inst. & Univ., Blacksburg, Va. 91 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WATERSHED, IMPACT, ECONOMICS Southern pine beetle control programs may include potential benefits for watershed quality. East Texas southern pine beetle activity data was used in hydrologic simulation models to estimate water quality components, erosion, nutrient loss, and water temperature. Water yield and water quality impacts were insignificant based on this data. Since water is generally a free good and has no market price, southern pine beetle control program benefits usually will not greatly affect watershed considerations.

898. **SHORE D. G., LEUSCHNER W. A.** 1977. Modeling the hydrologic impact of southern pine beetle attacks. Va. J. Sci. 28:55. (Abst.) (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT, ECONOMICS, WATERSHED Southern pine beetle impact on the water resource is modeled.

899. **SHORE D. G., LEUSCHNER W. A.** 1978. The economic implications of southern pine beetle attacks upon the hydrologic components of a forested watershed. Va. J. Sci. 29:47. (Abst.) (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT, ECONOMICS, WATERSHED Southern pine beetle had minor impact on water resources.

900. **SIKOROWSKI P. P., PABST G. S., TOMSON O.** 1979. The impact of diseases on southern pine beetle in Mississippi. Miss. Agric. For. Exp. Stn. Tech. Bull. 99. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, PATHOGENS, POPULATION DYNAMICS, CONTROL-BIOLOGICAL, NEMATODES, BACTERIA The incidence, identity and effect of disease on southern pine beetle populations were investigated in Mississippi. Pathogens detected included bacteria, fungi, nematodes, protozoa and possibly a virus. More than one-fifth of 60,472 beetles collected (larvae, pupae, and adults) from 175 sample trees were diseased.

901. **SILVERSTEIN R. M.** 1970. Attractant pheromones of Coleoptera. *In*, Chemicals controlling insect behavior, Academic Press, M. Beroza, Ed. N.Y. 170 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS, BEHAVIORAL CHEMICALS Reviews pheromones of Coleoptera.

902. **SILVERSTEIN R. M.** 1974. Collaborative studies of bark and ambrosia beetle pheromones. *In*, Southern Pine Beetle Symp., Payne, T. L., Coulson R. N., Thatcher R. C., Eds. March 7-8, 1974. Tex. Agric. Exp. Stn., College Station, Tex. p. 45-47. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Ips paraconfusus*, *Ips latidens*, *Ips pini*, *Trypodendron lineatum*, *Gnathotrichus sulcatus*). BEHAVIORAL CHEMICALS Behavioral aspects of pheromones of *Ips paraconfusus*, *Dendroctonus brevicomis*, *D. frontalis*, *Trypondendron lineatum* and *Gnathotrichus sulcatus* are discussed.

903. **SINCLAIR S. A.** 1978a. Utilization potential of beetle-killed southern pine sawtimber. Ph. D. Diss., Va. Polytech. Inst. & State Univ., Blacksburg, Va. 106 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, WOOD UTILIZATION Twelve months after foliage has faded the lumber grade recovery is significantly lower, and after 20 months it is drastically reduced. Decay and borer damage are the leading causes of grade loss when utilizing southern pine beetle killed trees. Utilization may be profitable if harvesting is economical, if it is not too heavily penalized by grading rules, and if the market conditions are favorable.

904. **SINCLAIR S. A.** 1978b. Profits from beetle-killed pine? Yes! Timber Process Ind.3:31-33. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION Beetle-killed pine can be used for products at a profit.

905. **SINCLAIR S. A.** 1979. A mill operator's guide to profit on beetle-killed southern pine. USDA Comb. For. Pest Res. and Dev. South. Pine Beetle Handb. Agric. Handb. No. 555. 15 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, WOOD UTILIZATION Profit on beetle-killed

southern pine is based on mill costs, buying costs, selling price for lumber and amount of expected losses for using the timber.

906. **SINCLAIR S. A.** 1980. Sawmod: A tool for optimizing potential profit from beetle-killed southern pine sawtimber. Wood And Fiber 12:29-39. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, WOOD UTILIZATION An economic analysis is presented for using beetle-killed southern pines.

907. **SINCLAIR S. A., IFJU G.** 1977. Processing beetle-killed southern pine--An opinion survey in Virginia. South. Lumberman 235(2916):11-14. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION The results of a survey questionnaire concerning the processing of beetle-damaged sawtimber are discussed.

908. **SINCLAIR S. A., IFJU G.** 1979. Lumber quality of beetle-killed southern pine in Virginia. For. Prod. J. 29(4):18-22. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION Trees were harvested 12 months, 20 months, and 20 months after foliage fade in order to determine the potential grade yields of dimension lumber. Beetle-killed trees showed a lower lumber recovery factor. The primary causes of degradation were decay and large borer holes.

909. **SINCLAIR S. A., IFJU G., HEIKKENEN H. J.** 1977a. Bug boards--lumber yield and grade recovery from timber harvested from southern pine beetle infested forests. South. Lumberman 234(2900):9-11. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION The major causes of timber degradation from dead trees of 12 months were rot and many large borer holes, which are discussed in this paper.

910. **SINCLAIR S. A., IFJU G., HEIKKENEN H. J.** 1977b. Lumber yield and grade recovery from southern pine sawtimber after beetle attack. South. J. Appl. For. 1:17-20. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT Lumber processed shortly after mortality from southern pine beetle showed little degrade. Lumber yield and grade decreased in relation to length of time after pine mortality. Bluestain and checking increased rapidly.

911. **SINCLAIR S. A., IFJU G., JOHNSON J. A.** 1978. Changes in toughness of wood from beetle-killed shortleaf pine. For. Prod. J. 28(7):44-47. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION Both fracture toughness and traditional toughness showed losses in strength due to the effects of decay and stain fungi. The sensitivity and usage of both toughness tests is discussed.

912. **SINCLAIR S. A., MCLAIN T. E., IFJU G.** 1979a. Strength loss in small clear specimens of beetle-killed southern pine. For. Prod. J. 29(6):35-39. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION MOR is an expression of the magnitude of maximum fiber stress in bending; MOE is an indication of material stiffness. Beetle-killed shortleaf and loblolly pine trees with known dates of foliage fade, as well as healthy trees, were harvested and processed into lumber. Both MOR and MOE were determined for dead and healthy material. Significant reductions in both MOR and MOE were noted in material even when harvested within 12 months. It was found that measurements of ultimate crushing strength were shown to be relatively insensitive between faded trees and healthy trees.

913. **SINCLAIR S. A., MCLAIN T. E., IFJU G.** 1979b. Toughness of sap-stained southern pine salvaged after beetle attack. Wood And Fiber 11(1):66-72. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION Toughness generally decreased with increasing time between foliage fade and the harvest of southern pine beetle-killed sawtimber. Most toughness loss occurred in the first year after foliage fade. Tangentially loaded logs were tougher than radially loaded logs, and butt logs were tougher than upper logs.

914. **SKELLY J. M.** 1976. Levels of *Fomitopsis annosa* in root systems of southern pine beetle-attacked versus non-attacked trees. Proc. Southwide For. Dis. Workshop, Atlanta, Ga. June 15-17, 1976. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Heterobasidion annosum*). HOST SELECTION, PATHOGENS An association between high levels of *Heterobasidion annosum*) infection (causing growth reduction) and bark beetle attack is proposed and discussed.

915. **SKELLY J. M., ALEXANDER S. A., WEBB R. S.** 1981. Gulf Costal Plain, association of annosus root rot with southern pine beetle attacks. *In*, Site, stand and host characteristics of southern pine beetle infestations, J. E. Coster and J. L. Searcy, Eds. USDA Comb. For. Pest Res. and Dev. Prog. Tech. Bull. 1612. p. 50-68. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Heterobasidion annosum*). PATHOGENS, HAZARD/RISK RATING, STAND CONDITIONS The association between annosus root rot and occurrence of southern pine beetle was greatest in thinned loblolly pine plantations. Between southern pine beetle-infested and uninfested trees, the annual radial growth was significantly greater in uninfested trees, suggesting that southern pine beetle-infested trees were less vigorous. On deep, sandy soils (high-hazard annosus root rot sites) the incidence and/or severity of southern pine beetle infestations is associated with reduced growth rates. This reduced growth (vigor) is due, in part, to high disease levels of *H. annosum* in the root system.

916. **SMILEY R. L.** 1969. Further studies on Tarsonemidae, II . (Acarina). Proc. Entomol. Soc. Wash. 71(2):218-229. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. ACARINA: TARSONEMIDAE. *Acalitus vaccinii*). TAXONOMY, MITES Mites associated with the southern pine beetle are discussed.

917. **SMILEY R. L., MOSER J. C.** 1968. New species of mites from pine. Proc. Entomol. Soc. Wash. 70(4):307-317. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. ACARINA: TARSOCHELIDAE; EUPALOPSELLIDAE; CALIGONELLIDAE; CRYPTOGNATHIDAE; RAPHIGNATHIDAE). PREDATOR, PARASITES, TAXONOMY, COMMENSALISM AND SYMBIOSIS, MORPHOLOGY AND PHYSIOLOGY, MITES New species of mites were described associated with *Dendroctonus frontalis*. These mites are: Tarsochelidae, *Heplocheylus pickardi*; Caligonellidae, *Molothrognathus rosei*; Neophyllobiidae, *Neophyllobius lorioi*; Cryptognathidae, *Cryptognathus barrasi*; Eupalopsellidae, *Paracupalopsellus hodgesi*; Raphignothidae, *Neoraphignathus howei*.

918. **SMILEY R. L., MOSER J. C.** 1970. Three Cheyletids found with pine bark beetles (Acarina: Cheyletidae). Proc. Entomol. Soc. Wash. 72:229-236. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. ACARINA: CHEYLETDAE; *Acarocheyla* spp., *Prosocheyla* spp.). PREDATOR, PARASITES, TAXONOMY, COMMENSALISM AND SYMBIOSIS, MITES Three cheyletid mites were found associated with southern pine bark beetles. These mites were *Acarocheyla impolita*, *A. virginiensis* and *Prosocheyla acanthus*.

919. **SMILEY R. L., MOSER J. C.** 1974. New Tarsonemids associated with bark beetles (Acarina: Tarsonemidae). Ann. Entomol. Soc. Am. 67:639-665. (COLEOPTERA: SCOLYTIDAE; ACARINA: TARSONEMIDAE). PREDATOR, PARASITES, ECOLOGICAL DISTRIBUTION, MISCELLANEOUS TECHNIQUES, MITES Three tarsonemid mites, *Tarsonemus ips*, *T. krantzi*, and *T. wilkinsoni*, are described associated with the southern pine beetle; the latter two were new species. Other tarsonemids are described.

920. **SMILEY R. L., MOSER J. C.** 1975. Redescription of *Eutogenes vicinus* Summers and Price, a predatory polymorphic, Cheyletid mite with descriptions of males and immature stages (Acarina: Cheyletidae). Proc. Entomol. Soc. Wash. 77:405-418. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus*). MORPHOLOGY AND PHYSIOLOGY, MITES The authors redescribe the mite, *Eutogenes vicinus*, collected from *Pinus taeda* infested with *Dendroctonus frontalis*.

921. **SMILEY R. L., MOSER J. C.** 1976. Two new phoretomorphic *Siteroptes* from galleries of the southern pine beetle (Acarina: Pyemotidae). Beitr. Entomol. 26:307-322. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, ACARINA: PYEMOTIDAE; *Siteroptes fusarii*, *Siteroptes trichoderma*). PREDATOR, PARASITES, REARING, TAXONOMY This paper provides taxonomic descriptions and biologies of two pyemotid mite species found in the galleries of *Dendroctonus frontalis*. There are 37 drawings and photos in the text.

922. **SMITH J. D., TWARDUS D. B.** 1979. Evaluation of a southern pine beetle control tactic: A case study for symposium participants. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 106-111. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES This paper presents subject matter suitable for study group use in developing an approach to treatment effectiveness evaluation. Cut-and-leave is the control strategy which is studied.

923. **SMITH M. T.** 1978. The life history and role of *Corticeus glaber* (LeC.) and *Corticeus parallelus* (Melsh.) (Coleoptera: Tenebrionidae) in association with the southern pine beetle, *Dendroctonus frontalis* Zimm. M. S. Thesis, La. State Univ., Baton Rouge, La. 89 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. TENEBRIONIDAE; *Corticeus glaber*, *Corticeus parallelus*). PREDATOR, SEASONAL OCCURRENCE, TRAPS AND CAGES Sticky traps were used to monitor the sequence of arrival of *Corticeus* spp. to trees attacked by the southern pine beetle. Arrival occurred from 0-14 days after mass attack. Egg gallery lengths of southern pine beetle and *Corticeus* spp. were positively correlated in the bottom and mid-bole regions but not in the top of the tree. *C. glaber* and C. parallelus were found to be facultative predators of southern pine beetle under laboratory conditions.

924. **SMITH M. T., GOYER R. A.** 1980. Relative abundance and seasonal occurrence of *Corticeus glaber* and *Corticeus parallelus* (Coleoptera: Tenebrionidae), associates of the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 112:515-519. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Corticeus glaber*, *Corticeus parallelus*). EGG, DISTRIBUTION, MISCELLANEOUS TECHNIQUES During a 15-month study, *Corticeus glaber* outnumbered *C. parallelus* on three sample heights on infested tree boles. Both species were significantly correlated with southern pine beetle eggs in the two lower sample heights, but not the upper.

925. **SMITH M. T., GOYER R. A.** 1982. The life cycle of *Corticeus glaber* (Coleoptera: Tenebrionidae), a facultative predator of the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 115:535-537. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. TENEBRIONIDAE; *Corticeus glaber*). PREDATOR Developmental time for *C. glaber* ranged from 30 to 41 days and five larval instars were determined.

926. **SMITH R. H.** 1972. Xylem resin in the resistance of the Pinaceae to bark beetles. USDA For. Serv. Gen. Tech. Rep. PSW-1. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). ATTRACTANTS, HOST SELECTION, HOST RESISTANCE Xylem resin of pines is closely associated with their resistance and susceptibility to bark beetles. A literature review suggests that preference (by attraction, repellency and synergism), antibiosis (by physical and chemical properties), and tolerance (by healing and secondary resinosis) are active in this association.

927. **SMITH R. K.** 1961. Where we stand...a roundup of primary pests and areas of infestation. For. Farmer 21(1):8-9,23-24. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). CONTROL-GENERAL Brief summaries of economic losses and controls for several insect pests are given.

928. **SMITH R. K.** 1962. Pine beetles in the South. For. Farmer 21(12):4-6,23. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips* spp.). SURVEY AND DETECTION General review of pine bark beetles.

929. **SMITH R. K.** 1963. Southern pine beetle outlook. For. Farmer 22(5):6-7,18-19. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION The status of the southern pine beetle is discussed for the southeastern United States.

930. **SMITH V. K.** 1954. Summary of attempts to rear *Dendroctonus frontalis* during the summer of 1954. Miss. State Coll., Starkville, Miss. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REARING Rearing of the southern pine beetle is reviewed.

931. **SNYDER T. E.** 1935. Bark beetles in relation to selective cutting. Nav. Stores Rev. 45:15. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, FIRE In selective logging operations, care should be taken to damage the residual stand as little as possible when felling crop trees and removing logs from the woods. When controlled burning is done, tree trunks should not be scorched by fire. When southern pine beetle infested trees occur in large groups, it is necessary to fell the trees, bark the logs and burn the bark.

932. **SOMERS G. L., ODERWALD R. G., HARMS W. R., LANGDON O. G.** 1980. Predicting mortality with a Weibull Distribution. For. Sci. 26:291-300. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). MODELING, STATISTICS The Weibull distribution is used to predict mortality.

933. **SOUTH CAROLINA STATE COMMISSION.** No date. Southern pine bark beetles. S. C. State Comm. For. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). LIFE HISTORY-GENERAL, ECOLOGICAL DISTRIBUTION, CONTROL-GENERAL, CONTROL-CULTURAL, SURVEY AND DETECTION Describes the life history and habits of the southern pine bark beetle complex in southern pines. Includes signs of attack, prevention of attack (removing weakened trees, looking for trees damaged or stressed by storms or drought), and control tactics, including felling and limbing, felling and barking, and rapid utilization.

934. **SPEERS C. F.** 1956. Radioisotopes in forest insect studies. Assoc. South. Agric. Worker's Proc. 53:130. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). RADIOGRAPHY, FLIGHT Briefly summarizes research looking at southern pine beetle flight habits (abstract only).

935. **SPEERS C. F., MERKEL E. P., EBEL B.** 1956. Tests of insecticides for the control of the southern pine beetle in North Carolina. (Abstract). Assoc. South. Agric. Worker's Proc. 53:100. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Insecticide tests are presented.

936. **ST. GEORGE R. A.** 1924. Southern pine beetle and other insect enemies of southern forests. Lumber Trade J. 86(9):37,38. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL Briefly describes insect enemies of southern forest trees.

937. **ST. GEORGE R. A.** 1925. The recent death of large quantities of southern pine. Am. Lumberman 2607:50-51. (COLEOPTERA; SCOLYTIDAE; *Dendroctonus frontalis*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). LIFE HISTORY-GENERAL, CONTROL-CULTURAL, SURVEY AND DETECTION Reviews life history of the southern pine beetle. Discusses losses in eastern Texas, Louisiana, southern Mississippi and western Alabama. Southern pine beetle in concert with *Ips* and drought conditions caused extensive mortality. Recommendations included salvaging timber.

938. **ST. GEORGE R. A.** 1930. Drought-affected and injured trees attractive to bark beetles. J. Econ. Entomol. 23:825-828. (COLEOPTERA: SCOLYTIDAE; *Ips calligraphus*, *Ips grandicollis*, *Scolytus quadrispinosus*). WEATHER RELATIONSHIPS The attractiveness of drought-stressed and injured pine trees to southern pine beetle in 1930 is discussed.

939. **ST. GEORGE R. A.** 1931. An instance of natural control of the southern pine beetle. For. Worker 7(6):16-17. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, HOST RESISTANCE, WEATHER RELATIONSHIPS A decline in overwintering southern pine beetle populations was probably caused by excessive moisture in the inner bark. Activities of the hairy woodpecker had an impact on the southern pine beetle brood.

940. **ST. GEORGE R. A., BEAL J. A.** 1929. The southen pine beetle: A serious enemy of pines in the South. USDA Farmers' Bull. 1586. 18 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL A description of beetle outbreaks, attack, biology, and control measures is presented. Other beetles likely to be mistaken for, or associated with the southern pine beetle are described.

941. **STEIN C. R.** 1975. Seasonal and height distribution of predators and parasites of the southern pine beetle (Coleoptera: Scolytidae) in two species of pine in East Texas. M. S. For. Thesis, Stephen F. Austin State Univ. Nacogdoches, Tex. 91 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, ECOLOGICAL DISTRIBUTION, DISTRIBUTION, PARASITES Twelve predator and nine parasite species were collected from shortleaf and loblolly pines over a ten month period. There was significant variation in parasite density by season but predator abundance did not vary. More parasites emerged from shortleaf than from loblolly pine. There was no significant difference in emergence from three sample heights.

942. **STEIN C. R., COSTER J. E.** 1977. Distribution of some predators and parasites of the southern pine beetle in two species of pine. Environ. Entomol. 6:689-694. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, DISTRIBUTION Twelve predators and nine parasites comprised about 99% of the southern pine beetle's natural enemy complex. The total predator density did not vary with tree species or season. The total parasite density was lowest in late winter, highest in midsummer, and higher in shortleaf. The effect of season, sample tree height, and tree species upon the number and distribution of predators and parasites was studied.

943. **STEPHEN F. M., COULSON R. N.** 1980. The southern pine beetle modeling symposium--An introduction and overview. *In*, Modeling Southern Pine Beetle Popul. Feb.,1980. Asheville, N. C. Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 1-3. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING The authors give the rationale and overview of the southern pine beetle modeling symposium. The scope of the modeling symposium is covered.

944. **STEPHEN F. M., KINN D. N.** 1980. Spatial distribution of mite associates of within-tree populations of *Dendroctonus frontalis* Zimm. Environ. Entomol. 9:713-715. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Trichouropoda australis, Tarsonemus krantzi, Dendrolaelaps neodisetus*). PREDATOR, PARASITES, MITES Mite diversity was greatest in southern pine beetle populations collected from the upper bole. The most common mite species were *Dendrolaelaps neodisetus, Trichouropoda australis* and *Tarsonemus krantzi*.

945. **STEPHEN F. M., SEARCY J. L., HERTEL G. D., EDS.** 1980. Modeling southern pine beetle populations, Symp. Proc., Asheville, N. C., Feb. 20-22, 1980. USDA For. Serv. Tech. Bull. No. 1630. 174 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, POPULATION DYNAMICS Papers on southern pine beetle modeling and population dynamics are presented.

946. **STEPHEN F. M., TAHA H. A.** 1976. Optimization of sampling effort for within-tree populations of southern pine beetle and its natural enemies. Environ. Entomol. 5:1001-1007. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, STATISTICAL METHODS, MODELING, PREDATOR, PARASITES An optimum sample unit size was developed for the southern pine beetle and its natural enemies, as a function of attack density, egg gallery length, total brood, parasite complex, and predator complex. Computer programs were developed for the experimental sample unit sizes. The relationship of sample number to sample unit size was determined, and a procedure for estimating bark beetle and its natural enemy population density was outlined.

947. **STEPHEN F. M., TAHA H. A.** 1979a. Area-wide estimation of southern pine beetle populations. Environ. Entomol. 8:850-855. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING A mathematical model and procedure utilizing aerial and ground surveys as well as within-tree sampling was developed in order to estimate absolute numbers of southern pine beetles in forest stands. This procedure and model are useful for area-wide southern pine beetle estimation, but not for within-tree southern pine beetle infestations.

948. **STEPHEN F. M., TAHA H. A.** 1979b. Tree mortality, infested bark area, and beetle population measurements as components of treatment evaluation procedures on discrete forest management units. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J . L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 45-53. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, DISTRIBUTION, SURVEY AND DETECTION Area-wide estimation of *Dendroctonus frontalis* populations in Arkansas used aerial surveys, ground surveys, age structure estimation, beetle density estimation, and infested bark area estimation. Intensive within-tree sampling was not necessary since the population estimation technique proposed makes use of an existing data base. This procedure is relatively simple, inexpensive, and can be used to obtain pre- and post-treatment southern pine beetle population estimates. However, since no direct measurements are made of average beetle density within the infested trees, the procedure cannot be used to measure the effect of any treatment on the density of within-tree beetle populations.

949. **STERRETT W. O.** 1914. Forest management of loblolly pine in Delaware, Maryland, and Virginia. USDA Bull. No. 11. p. 10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS Lists the southern pine beetle as the major insect pest of loblolly pine; refers the readers to Hopkins' 1911 publication (USDA Farmers' Bull. No. 476).

950. **STEWART T. E., PLUMMER E. L., MCCANDLESS L. L., WEST J. R., SILVERSTEIN R. M.** 1977. Determination of enantiomer composition of several bicyclic ketal insect pheromone components. J. Chem. Ecol. 3:27-43. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus brevicomis, Scolytus multistriatus*). BEHAVIORAL CHEMICALS The use of a chiral shift reagent for determining enantiomer compositions of several bark beetle pheromone components (bicyclic ketals) is explained in detail. *Dendroctonus brevicomis, D. frontalis* and *Scolytus multistriatus* were used in the experiments, as well as synthetic *exo*-brevicomin, and frontalin (and their enantiomers), synthetic *alpha*-multistriatin, and natural *exo*-brevicomin, frontalin and *alpha*-multistriatin. NMR spectrums for each pheromone are presented and their significance discussed.

951. **STIMAC J. L., CAMBELL R. W.** 1980. Summary remarks and evaluation. *In*, Modeling Southern Pine Beetle Popul., Symp. Proc., Feb., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 172-174. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, POPULATION DYNAMICS The modeling symposium is critiqued.

952. **STRONG L. A.** 1938. Report of the Chief of the Bureau of Entomology and Plant Quarantine, 1938. USDA Bur. Entomol. and Plant Quarantine Rep. p. 17. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis. Enothanasimus lecontei, Temnochila virescens*). REVIEW The southern pine beetle was reported affecting forest and shade trees in 1938.

953. **STULTZ S.** 1977. Woodpeckers found helpful in southern pine beetle control. For. Farmer 36(6):9. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR,

PARASITES, VERTEBRATES, CONTROL-BIOLOGICAL The role of woodpeckers in the control of southern pine beetle is discussed.

954. **ŠVIHRA P.** 1982. Influence of the opposite sex on the attraction produced by the pioneer sex of four bark beetle species cohabiting pine in the southern United States. J. Chem. Ecol. 8:373-378. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips calligraphus, Ips grandicollis, Ips avulsus*). BEHAVIORAL CHEMICALS, HOST SELECTION Catches of *Dendroctonus frontalis* and *Ips avulsus* on traps surrounding bolts infested with both sexes of each species in the gallery were not significantly different from catches at bolts with only the sex that pioneers the tree.

955. **ŠVIHRA P., PAINE T. D., BIRCH M. C.** 1980. Interspecific olfactory communications in southern pine beetles. Naturwissenschaften 67:518-519. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*). AGGREGATION, ATTRACTANTS, POPULATION DYNAMICS Studies conducted confirmed the hypothesis that interspecific olfactory communication plays a significant role in defining the sequence and patterns of colonization by bark beetles (*D. frontalis, I. avulsus, I. calligraphus*, and *I. grandicollis*).

956. **SWAIN K. M. SR., REMION M. C.** 1981. Direct control methods for the southern pine beetle. USDA Comb. For. Pest Res. and Dev. Prog. Agric. Handb. No. 575. 15 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CHEMICAL, CONTROL-CULTURAL Direct control tactics for the southern pine beetle included salvage, cut-and-leave, chemicals and pile-and-burn. Treatment priorities are assigned with a guide based on attacked pines, pine basal area and average diameter. Symptoms of attacks by southern pine beetle are listed.

957. **SWAIN K. M., FOX W.** 1979. Control of the southern pine beetle on national forests. *In*, Evaluating Control Tactics for the South. Pine Beetle Symp. Proc. Jan 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 1-4. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, ECONOMICS, IMPACT, CONTROL-CULTURAL Direct and indirect control tactics of the southern pine beetle are discussed, with emphasis given to forest management practices. New tools are described, and new information needed to help manage pine stands and control southern pine beetle is presented.

958. **SWAINE J. M.** 1909. Catalogue of the described Scolytidae of America, north of Mexico. N. Y. State Mus. Bull. 134:76-159,169-194. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). TAXONOMY, REVIEW, DISTRIBUTION The distribution, hosts, and nomenclature are listed for North American bark beetles.

959. **SWAINE J. M.** 1925. The factors determining the distribution of North American bark beetles. Can. Entomol. 57:261-266. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). LIFE HISTORY-GENERAL, PREDATOR, PARASITES, ECOLOGICAL DISTRIBUTION, DISTRIBUTION The influence of the range and supply of host trees, climate, natural barriers, food and breeding habits, and natural enemies upon the distribution of 16 species of *Dendroctonus* is discussed.

960. **TAHA H. A., STEPHEN F. M.** 1981. Tactical problems in simulating biological systems. *In*, Proc. 1981 Summer Computer Simulation Conf., Washington, D. C. p. 76-78. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, POPULATION DYNAMICS, EGG, LARVAE , PUPAE, ADULT A simulation model for the life processes of the southern pine beetle is presented. The model can simulate development rates, mortality rates and populations. Comparisions are made for predicted and observed southern pine beetle populations.

961. **TAHA H. A., STEPHEN F. M., MOTAMEDI M.** 1980. Sensitivity analysis and uncertainty in estimation of rates for a southern pine beetle model. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980, Asheville N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 13-19. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING, MISCELLANEOUS TECHNIQUES, FLIGHT A new sensitivity analysis procedure is presented which may be used to determine the degree of importance of different rates of a southern pine beetle model. Results indicate that the inflight mortality of emerging and reemerging adults is the most important rate in the model discussed. Researchers can use this information to seek reliable estimates of the more important rates of the model .

962. **TAYLOR A. R.** 1974. Ecological aspects of lightning in forests. Proc. Annu. Tall Timbers Fire Conf. 13:455-482. (COLEOPTERA: SCOLYTIDAE). LIGHTNING, STAND CONDITIONS Lightning-struck trees often serve as reservoirs for bark beetles.

963. **TAYLOR J. F., MOORE G. E.** 1978. Evaluation of a technique for tagging southern pine beetles with selected radionuclides. J. Econ. Entomol. 71:677-679. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FLIGHT, RADIOGRAPHY, MISCELLANEOUS TECHNIQUES *Dendroctonus frontalis* beetles were tagged with several radionuclides. A portable ratemeter detected 74% of the ^{32}P-tagged southern pine beetle (a stationary counter detected 87%after nine days). ^{32}P was much more effective than all other radionuclides tested.

964. **TELFER W. G.** 1979. Reemergence, reattack and second brood production of the southern pine beetle *Dendroctonus frontalis* Zimmerman (Coleoptera: Scolytidae). M. S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Tex. 59 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, EMERGENCE, MISCELLANEOUS TECHNIQUES The role of reemerged parent adults in the population dynamics of the southern pine beetle is investigated. Fifty-four and eighty-two hundredths percent of the parent adults reemerged in laboratory studies. There was no difference between first and second reemergence rates. In field studies parent adult reemergence averaged 64.88%.

965. **TEXAS FOREST SERVICE.** 1950. The southern pine beetle -its occurrence and control in East Texas. Tex. For. Serv. Circ. No. 26, College Station, Tex. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp. PLATYPODIDAE; *Platypus* sp.). LIFE HISTORY-GENERAL, CONTROL-GENERAL, CONTROL-CHEMICAL, CONTROL-CULTURAL Describes life history of the southern pine beetle and association with blue stain fungus. Detection of the beetle is based on location of active and inactive infested areas in the forest. Spots may range in size from a few trees to upwards of 200 acres. Describes identification of trees with active brood. Associated bark beetles, including *Ips* spp., black turpentine beetle, and the ambrosia beetle, *Platypus* sp., are discussed. Felling of brood trees and chemicals for control of southern pine beetle are outlined.

966. **TEXAS FOREST SERVICE.** 1952a. Southern pine bark beetles. Tex. For. Serv. Bull. No. 33. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips grandicollis, Ips calligraphus*). LIFE HISTORY-GENERAL Biology, attack characteristics, prevention and control of southern pine beetle, *Ips* engraver beetles, and black turpentine beetles are described and discussed.

967. **TEXAS FOREST SERVICE.** 1952b. Insects and disease threaten forests. Tex. For. News 31(1):5-8. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). CONTROL-GENERAL, CONTROL-CULTURAL A general review of insect and disease problems in southern forests. A description of various insects and diseases including economic losses, recent epidemics, general life histories, and control practices. Briefly summarizes southern pine beetle life history and damages.

968. **TEXAS FOREST SERVICE.** 1967. Another year of the beetles. Tex. For. News 46(4):4, 11. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-

GENERAL, REVIEW The 1967 southern pine beetle outbreak is described for East Texas. The population declined slightly since 1966; about 89,000 trees were killed in 1967 compared to 96,000 in 1966.

969. **TEXAS FOREST SERVICE.** 1970a. Beetle control trials show promise. Tex. For. News 49:3-4. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, CONTROL-GENERAL, REVIEW The new frontalure-cacodylic acid southern pine beetle control technique is described and discussed. Frontalin and frontalure are described as they influence the behavior of southern pine beetle.

970. **TEXAS FOREST SERVICE.** 1970b. Forest pest activiy in Texas-1970. Tex. For. Serv. Circ. No. 205. 11 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, ECONOMICS, IMPACT Forest pest activity in Texas in 1970 is summarized and broken down by pests, area of infestation, and damage incurred.

971. **TEXAS FOREST SERVICE.** 1971a. Forest pest activity in Texas-1971. Tex. For. Serv. Circ. No. 210. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, ECONOMICS, IMPACT Forest pest activity in Texas in 1971 is summarized and broken down by pests, area of infestation, and damage incurred.

972. **TEXAS FOREST SERVICE.** 1971b. X-ray...new weapon against killer beetle. Tex. For. News 50:7. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, RADIOGRAPHY X-rays are used to detect bark beetles and their galleries in four inch bark discs which have been removed from trees treated with cacodylic acid and frontalure. The X-rays indicate how many beetles and predators are present, as well as their stage of maturity.

973. **TEXAS FOREST SERVICE.** 1973. SPB 15th verse. Tex. For. News 52:8-10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW, CONTROL-GENERAL A historical overview of the southern pine beetle in Texas is presented, and past and present control methods are weighed and discussed. Salvage operations, as the primary control method, are discussed.

974. **TEXAS FOREST SERVICE.** 1974. Texas forest pest activity 1972-1973 and forest pest control section annual report. Tex. For. Serv. Circ. No. 219. 16 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, ECONOMICS, IMPACT, REVIEW, INTEGRATED PEST MANAGEMENT, CONTROL-CULTURAL Southern pine beetles reached a peak level in 1972 and declined in 1973. A total of 5190 spots were detected in 1972; in 1973, 3853 spots were detected. Salvage was the most common control. Only one percent of the spots were controlled with BHC, the primary method of control prior to 1969. Almost 20 million board-feet of sawtimber and 18,000 cords of pulpwood were destroyed in 1973 in East Texas on Federal and private lands.

975. **TEXAS FOREST SERVICE.** 1975a. Cut and leave–A method to reduce losses from the southern pine beetle. Tex. For. Serv. Circ. 223. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CULTURAL Discusses the 'cut-and-leave' method of southern pine beetle control in Texas.

976. **TEXAS FOREST SERVICE.** 1975b. On the trail of the elusive southern pine beetle. Tex. For. News 54:6-10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL, CONTROL-CHEMICAL, CONTROL-CULTURAL, REVIEW The Texas Forest Service Operational Information System is described and discussed. Detection, reporting, checking, and control procedures are discussed.

977. **TEXAS FOREST SERVICE.** 1976a. Salvage–the preferred method to reduce losses from the southern pine beetle. Tex. For. Serv. Circ. 225. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, CONTROL-CULTURAL Describes how and when to apply the salvage control method of southern pine beetle in Texas.

978. **TEXAS FOREST SERVICE.** 1976b. Texas forest pest activity 1974-1975 and forest pest control section biennial report. Tex. For. Serv. Circ. 226. 19 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, ECONOMICS, IMPACT, BEHAVIOR The southern pine beetle was epidemic over 46.7 million acres southwide. Southern pine beetle in East Texas in 1974-1975 resulted in 12.3 and 9.95 million cubic feet volume killed for each year, respectively. Salvage and prompt logging were the preferred controls. Computer generated maps were produced for annual southern pine beetle activity.

979. **TEXAS FOREST SERVICE.** 1977a. Control of SPB spots. Tex. For. Serv. Pest Control Sec. Fact Sheet. 1 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, SURVEY AND DETECTION Cultural controls and detection of southern pine beetle spots are summarized for 1975 for East Texas.

980. **TEXAS FOREST SERVICE.** 1977b. Southern pine beetle-seasonal habits in East Texas forests. Tex. For. Serv. Circ. No. 228. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, REVIEW, BEHAVIOR, CONTROL-GENERAL Describes spring, summer, fall, and winter habits of the southern pine beetle, and direct and preventative control measures.

981. **TEXAS FOREST SERVICE.** 1978. Texas forest pest activity 1976-1977 and forest pest control section biennial report. Tex. For. Serv. Publ 117. 28 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*). CONTROL-GENERAL, ECONOMICS, IMPACT, BEHAVIOR, CONTROL-CULTURAL The southern pine beetle reached the peak of its epidemic in 1976. An estimated 213,552 board feet of sawlogs and 215,128 cords of pulpwood were destroyed in 1976. These numbers had declined to 42,631 and 66,879, respectively, by 1977. In East Texas, 34 counties were declared disaster areas. A summary of control tactics is presented. Salvage was the major cultural control practiced. BHC was used very little.

982. **TEXAS FOREST SERVICE.** 1980. Texas forest pest activity 1978-1979 and forest pest control section biennial report. Tex. For. Serv. Publ. No. 121. 21 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). DISTRIBUTION, ECONOMICS, BEHAVIOR, IMPACT, CONTROL-CHEMICAL, TRAPS AND CAGES, MISCELLANEOUS TECHNIQUES The southern pine beetle was at its lowest level in East Texas in 20 years in 1978-1979. Southern pine beetle research at the Texas Forest Service included southern pine beetle brood distribution, models of attack processes, use of non-sticky pheromone traps, and the relationship between aerial and ground estimates of spot size. A lag time of 33 days was found between detection and salvage, and three days between detection and cut-and-leave.

983. **TEXAS FOREST SERVICE.** 1981. Southern pine beetle–gone (temporarily), but not forgotten. Tex. For. News 60(Spring):12-13. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW, INTEGRATED PEST MANAGEMENT Reviews the southern pine beetle in East Texas. Reviews the Expanded Southern Pine Beetle Research Applications Program and technology transfer of information in 'How To' handbooks. Reviews the current Texas Forest Service two-county demonstration area in Polk and Tyler counties of East Texas, including hazard rating, direct control tactics with frontalin (back baiting), and salvage. The use of a portable sawmill for cutting lumber from beetle-killed timber is discussed.

984. **TEXAS FOREST SERVICE.** 1982. Texas forest pest report. Tex. For. Serv. Pub. 127. 39 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*. CERAMBYCIDAE; *Monochamus titillator*. CLERIDAE; *Thanasimus dubius*). SURVEY AND DETECTION, INTEGRATED PEST MANAGEMENT, TECHNOLOGY TRANSFER, HAZARD/RISK RATING, ATTRACTANTS, TRAPS AND CAGES Populations of the southern pine beetle had declined in East Texas to very low levels. The southern pine beetle demonstration project was discussed including hazard mapping,

computer systems to aid IPM, a portable sawmill, and technology. Bark beetle research includes evaluation of trap designs, pheromone response by bark beetle associates, and baiting pines to induce *Ips* attacks. An insect and disease survey indicated the southern pine beetle as the number one pest in East Texas.

985. **THATCHER R. C.** 1960. Bark beetles affecting southern pines: Review of current knowledge. USDA For. Serv. Occ. Pap. 180. 25 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). REVIEW Thatcher summarizes current knowledge of the southern pine beetle.

986. **THATCHER R. C.** 1967. Winter brood development of the southern pine beetle in southeast Texas. J. Econ. Entomol. 60:599-600. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips calligraphus, Ips grandicollis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS, EMERGENCE, PREDATOR Brood development accelerated during mid-January through February when daily temperatures exceeded 50 degrees F. Emerging adults attacked basal stems and lower crown areas of unattacked trees by February. Woodpecker activity occurred only when southern pine beetle brood had advanced to the mid- and late-larval stages.

987. **THATCHER R. C.** 1971. Seasonal behavior of the southern pine beetle in central Louisiana. Ph.D. Diss., Auburn Univ., Auburn, Ala. 102 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp. *Phytophthora cinnamomi, Phythium* spp.). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS, FLIGHT, HOST RESISTANCE, WEATHER RELATIONSHIPS, LIGHTNING Mid- and upper-bole regions of trees were attacked during cooler months, and the lower third of the bole in summer. Brood survival was found to be highest from late fall through early spring, with reduced survival in late summer. Populations were highest in April through early June and also in September and October. When beetle populations were at reduced levels, lightning-struck trees often served as reservoirs for developing infestations.

988. **THATCHER R. C.** 1973. The current southern pine beetle situation. Southern pine beetle - A management challenge. Entomol. Soc. Am. Natl. Meet., Dallas, Tex. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). REVIEW, INTEGRATED PEST MANAGEMENT, STAND CONDITIONS Thatcher reviews the impact and occurrence of the southern pine beetle, including stand conditions, associated organisms, the development of the International Biological Program, and alternative forest management strategies. The paper provides a conceptual framework for others at the Entomol. Soc. Am. meeting.

989. **THATCHER R. C.** 1974. Past and present approaches to southern pine beetle research-an overview. *In*, Southern Pine Beetle Symp., Payne T. L., Coulson R. N., Thatcher R. C., Eds., March 7-8, 1974. Tex. Agric. Exp. Stn., College Station, Tex. p. 8-11. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, POPULATION DYNAMICS, ATTRACTANTS, SURVEY AND DETECTION, REVIEW, WEATHER RELATIONSHIPS Past and present research developments and approaches to southern pine beetle study and control are described.

990. **THATCHER R. C.** 1977. Status of the Expanded Pine Beetle Research Program. For. Farmer 36(6):8-9. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, INTEGRATED PEST MANAGEMENT Reviews the status of the Expanded Southern Pine Beetle Research and Applications Program after its second field season. Three phases of the program are outlined: During Phase I, a stand projection model was refined and a theoretical beetle attack probability model developed; utilization, sampling, hazard-rating, and relationship to diseases are included; Phase II was concerned with behavioral chemicals, toxicants, and stand manipulation; and Phase III included the integration and technology transfer phase.

991. **THATCHER R. C.** 1979a. Impact of forest pests on multiple-use management decisions. *In*, Multiple-Use Manage. For. Resour. Symp. Proc., Sept., 1979. Clemson., S. C., Hook D. D., Dunn B. A., Eds., p. 77-83. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW, CONTROL-GENERAL Thatcher summarizes southern pine beetle preventions and controls.

992. **THATCHER R. C.** 1979b. Organization and implementation of comprehensive research and development on the gypsy moth, Douglas-fir tussock moth and southern pine beetle in the United States. *In*, Current Topics in For. Entomol., Selected Pap. from XVth Internatl. Congr. Entomol., Wash., D C. Aug., 1976., W. E. Waters, Ed. USDA Gen. Tech. Rep. W0-8. p. 64-67. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). INTEGRATED PEST MANAGEMENT The organization of the large-scale management programs are presented. Included are goals and charts for running these programs.

993. **THATCHER R. C.** 1980a. Chapter 1. Introduction. *In*, The southern pine beetle. R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. D. Hertel, Eds. USDA Expanded South. Pine Beetle Res. Appl. Prog. For. Serv. Sci. and Educ. Tech. Bull. 1631. p. 1-4. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). INTEGRATED PEST MANAGEMENT Thatcher summarizes the Expanded Southern Pine Beetle Research Applications Program (ESPBRAP) planning, organization, and management. Management goals were to: 1) develop technology to predict damage and population trends, 2) develop models for managing beetle populations and forest stands to minimize damage, and 3) integrate technology from the program. Technology transfer of results and post-program needs are discussed.

994. **THATCHER R. C.** 1980b. Latest developments in southern pine beetle prevention and control. For. Farmer 39(9):16,22. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW, INTEGRATED PEST MANAGEMENT Review of the ESPBRAP program.

995. **THATCHER R. C.** 1982. The development of integrated management strategies for the southern pine beetle. *In*, Increasing forest productivity. Proc. 1981 Soc. Am. For. Natl. Meet., Orlando, Fla. p. 177-184. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). INTEGRATED PEST MANAGEMENT, CONTROL-GENERAL Thatcher reviews IPM and stresses the concept of southern pine beetle management by contact between user groups.

996. **THATCHER R. C., COSTER J. E., PAYNE T. L.** 1978. Southern pine beetles can kill your ornamental pine. USDA Comb. For. Pest Res. and Dev. Prog., Home and Garden Bull. No. 226. 15 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL An overview is given for the southern pine beetles which may damage ornamental pines, including their appearance and life cycles, associated beetles, damage, symptoms, susceptible pines, prevention, and control.

997a **THATCHER R. C., MASON G. N., HERTEL G. D., SEARCY J. L.** 1981. New combined program for management of forest pests. For. Farmer 40(10):12. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, WEATHER RELATIONSHIPS The accomplishments of the IPM program are reviewed in detail by subject area.

997b **THATCHER R. C., MASON G. N., HERTEL G. D., SEARCY J. L.** 1982. Detecting and controlling the southern pine beetle. South. J. Appl. For. 6:153-159. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, SURVEY AND DETECTION, REVIEW Detection, evaluation, suppression and prevention of *D. frontalis* are reviewed. Preventative silvicultural guidelines are also prescribed.

997c **THATCHER R. C., BARRY P. J.** 1982. Southern pine beetle. USDA For. Serv. For. Insect and Dis. Leafl. 49. 6 p.

(COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL GENERAL. The life history and controls for the southern pine beetle are presented.

998. **THATCHER R. C., PICKARD L. S.** 1964. Seasonal variations in activity of the southern pine beetle in East Texas. J. Econ. Entomol. 57:840-842. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, WEATHER RELATIONSHIPS Southern pine beetle populations in East Texas during 1960-1962 increased 2 or 3 to 1 for each generation during the late fall or early spring. Infestation number and size increased most rapidly from April through June. Beetles attacked upper stems during the cooler months and the lower third of stems in midsummer. Midsummer high temperatures apparently limited dispersal and survival. Artificial control measures, such as salvage, should be intensified from the fall to the early spring.

999. **THATCHER R. C., PICKARD L. S.** 1966. The clerid beetle, *Thanasimus dubius*, as a predator of the southern pine beetle. J. Econ. Entomol. 59:955-957. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, CONTROL-GENERAL Adult clerid beetles, *Thanasimus dubius*, killed an average of 2.2 adult southern pine beetles per day for five to ten weeks. In the laboratory, larva of *T. dubius* may destroy more than 100 immature southern pine beetles. Recommendations are made to preserve *T. dubius* populations in southern pine beetle control programs.

1000. **THATCHER R. C., PICKARD L. S.** 1967. Seasonal development of the southern pine beetle in East Texas. J. Econ. Entomol. 60:656-658. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, REARING The southern pine beetle passed through seven (and a partial eight) generations in field-infested bolts in 1962 in East Texas. A summer generation was completed in as few as 26 days, but required up to three and one-half months in the winter.

1001. **THATCHER R. C., SEARCY J. L., COSTER J. E., HERTEL G. D., Eds.** 1980. The southern pine beetle. USDA For. Serv. and Sci. and Educ. Admin., Tech. Bull. No. 1631. 266 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus, Ips calligraphus, Ips grandicollis*. CLERIDAE; *Thanasimus dubius*). INTEGRATED PEST MANAGEMENT, TECHNOLOGY TRANSFER, CONTROL-GENERAL, LIFE HISTORY-GENERAL, STAND CONDITIONS, POPULATION DYNAMICS, ECONOMICS, HAZARD/RISK RATING, MODELING, BEHAVIOR, UTILIZATION, SAMPLING, MITES, PREDATOR, PARASITES The ESPBRAP is summarized by participants in the program. Included are chapters on life history, natural enemies, site/stand conditions, population dynamics and sampling, hazard/risk rating, controls, impact, and integrated pest management.

1002. **THATCHER R. C., WILSON J. G.** 1982. Bibliography of southern pine beetle program publications. USDA For. Serv. South. For. Exp. Stn. Special Rep., New Orleans, La. 25 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW Bibliography of the Expanded Southern Pine Beetle Research Applications Program.

1003. **THOMAS H. A., RICHMOND J. A., BRADLEY E. L.** 1981. Bioassay of pine bark extracts as biting stimulants for the southern pine beetle. USDA For. Serv. Res. Note SE-302. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MISCELLANEOUS TECHNIQUES, BEHAVIOR Extracts from five species of southern pines were compared in their effectiveness in eliciting biting responses of the southern pine beetle. Extracts from the outer bark of shortleaf pine elicited the greatest number of biting responses.

1004. **THOMAS H. A., WHITE J. D., SPEERS C. F., CONRAD H.** 1975. Dispensing pressurized aerosols of southern pine beetle pheromone under field conditions. J. Ga. Entomol. Soc. 10:265-271. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, MISCELLANEOUS TECHNIQUES An aerosol formulation of the synthetic southern pine beetle pheromone, Frontalure-33, *alpha*-pinene and 1,5-dimethyl-6,8-dioxabicyclo-(3.2.1.)octane was formulated in a 1% solution of Freon. The aerosol dispenser investigated would have to be improved for repeatable research studies.

1005. **THOMAS J. B.** 1965. The use of larval anatomy in the study of bark beetles (Coleoptera: Scolytidae). Can. Entomol. Supplement 5. 45 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*). MORPHOLOGY AND PHYSIOLOGY The immature stages of the genus *Dendroctonus* are described and illustrated.

1006. **THOMAS J. B.** 1967. A comparative study of gastric caeca in adult and larval stages of bark beetles (Coleoptera: Scolytidae). Proc. Entomol. Soc. Ont. 97:71-90. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis,*). MORPHOLOGY AND PHYSIOLOGY Gastric caeca were diagrammed for 87 species of bark beetles in 27 genera. *Dendroctonus frontalis* had small numbers of gastric caeca, particularly in the larvae. The caeca were arranged in a band or group on either side of the midgut.

1007. **TOKO H. V., LANDGRAF A. E.** 1979. Southern pine beetle outbreak looks serious. For. Farmer 39(2):10-11,29-30. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, ECONOMICS, IMPACT Discusses the 1978 southern pine beetle outbreak in the southeastern United States. Possible causes of the outbreak were tree stress induced by drought and overstocked stands. Suppression efforts should be coupled with adequate aerial and ground detection.

1008. **TOMESCU N. I., CLARK E. W.** 1976. Technique for sexing the pupae of *Dendroctonus frontalis*. J. Ga. Entomol. Soc. 11:170-172. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PUPAE, SEX-RATIOS, MORPHOLOGY AND PHYSIOLOGY Morphological differences on the posteroventral abdominal tip of the pupae can be used to distinguish the sexes. The most obvious difference is the configuration of the tenth tergite.

1009. **TOMESCU N., CLARK E., WHITE J., THOMAS H.** 1978. Factors influencing response of *Dendroctonus frontalis* (Coleoptera, Scolytidae) to beetle- and host-produced attractants. Trav. Mus. Hist. Nat. 'Grigore Antipa' 19:285-288. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, HOST SELECTION, BEHAVIOR Responses of adult *Dendroctonus frontalis* were measured to beetle- and host-produced attractants. Responses of males to frontalin and three host monoterpenes were in these categories of increasing intensity: host terpenes, frontalin and combinations of these two categories. Frontalin mixed with monoterpenes (1:19) was 2-3 times more attractive than frontalure alone. Females showed the same responses as males, but with a lower magnitude of response.

1010. **TRIPLEHORN C. A., MOSER J. C.** 1970. Two new species of *Corticeus* from Mexico and Honduras (Coleoptera: Tenebrionidae). Coleopt. Bull. 24:47-50. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. TENEBRIONIDAE; *Corticeus coynei, Corticeus rosei*). TAXONOMY The two species of *Corticeus* as associates of *Dendroctonus frontalis* are described.

1011. **TSAO C. H.** 1966. Flight activity and response to light in the southern pine beetle (*Dendroctonus frontalis* Zimm.). J. Ga. Entomol. Soc. 1:11-16. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FLIGHT Southern pine beetle adults were attracted to both incandescent and ultraviolet light, and were negatively geotactic in the dark. Beetles emerged from infested bolts mainly during daylight hours.

1012. **TSAO C. H., YU C.** 1967. Sex pheromones of the southern pine beetle, *Dendroctonus frontalis* Zimm., (Coleoptera: Scolytidae). J. Ga. Entomol. Soc. 2:13-20. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, MISCELLANEOUS TECHNIQUES Pheromones were found in the boring frass and bodies of the southern pine beetle. Sensitive bio-assay techniques were developed. Extracts of females that mated were less attractive than that produced by virgin females. The crushed parts of either sex were attractive to both sexes.

1013. **TURNBOW R. H. JR., FRANKLIN R. T.** 1980. Flight activity by Scolytidae in the Northeast Georgia Piedmont (Coleoptera). J. Ga. Entomol. Soc. 15:26-37. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SEASONAL OCCURRENCE, ECOLOGICAL DISTRIBUTION, FLIGHT, BEHAVIOR Flight activity of scolytids were monitored in northeast Georgia mixed pine-hardwood forest using window traps. Specimens of *Dendroctonus frontalis* were captured from March through November in 1976 and February and March in 1977. Adults were active above 20 degrees C. Several peak flight times reflect the multi-generation habit of the beetle.

1014. **TURNBOW R. H. JR., FRANKLIN R. T., NAGEL W. P.** 1978. Prey consumption and longevity of adult *Thanasimus dubius*. Environ. Entomol. 7:695-697. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, PARASITES, CONTROL-BIOLOGICAL, BEHAVIOR Mean daily prey consumption of southern pine beetle adults by *Thanasimus dubius* was 1.28. Prey consumption for ovipositing females increased to 2.48 southern pine beetles per day. Non-ovipositing females consume more prey than males, but this may be due to the female's larger size.

1015. **TURNBOW R. H., COULSON R. N., HU L., BILLINGS R. F.** 1982. Procedural guide for using the interactive version of the TAMBEETLE model of southern pine beetle population and spot dynamics. Tex. A&M Agric. Exp. Stn. MP-1518, College Station, Tex. 25 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). INTEGRATED PEST MANAGEMENT, SAMPLING, MODELING, POPULATION DYNAMICS TAMBEETLE is a biophysical, mechanistic model of southern pine beetle population and spot dynamics. The TAMBEETLE model integrates mechanisms describing the distribution of attacks on and between trees using beetle life process model, variable stand density, and microclimate conditions. An interactive, user-oriented version is described and a sample run is included.

1016. **TURNBOW R. H., FRANKLIN R. T.** 1979. *Hyalomyodes triangulifera* (Diptera: Tachinidae: A parasite of the southern pine beetle predator *Thanasimus dubius* (Coleoptera: Cleridae). J. Ga. Entomol. Soc. 14:174-176. (COLEOPTERA: CLERIDAE; *Thanasimus dubius*. SCOLYTIDAE; *Dendroctonus frontalis*. DIPTERA: TACHINIDAE; *Hyalomyodes triangulifera*). PREDATOR, PARASITES Development of the tachinid *Hyalomyodes triangulifera* in the clerid *Thanasimus dubius* is described.

1017. **TWARDUS D. B.** 1976. Current status of southern pine beetle threat. For. Farmer 36(2):24,34. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, ECONOMICS, IMPACT, REVIEW Southern pine beetle attacks were reported on a downswing except for East Texas, Arkansas, Louisiana and Mississippi. Rapid salvage of infested material was the primary suppression method. Continued cooperation among private, State, and Federal agencies is essential to southern pine beetle control.

1018. **UHLER R. J.** 1980. The ESPBRAP site-stand data file. Southern pine beetle fact sheet number 11. USDA For. Bull. SA-FB/P26. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, REVIEW Data files from the ESPBRAP are summarized as to their content.

1019. **UPTON R. G.** 1945. Bark beetles of the pines of Stephen F. Austin State Teachers College. Trans. Tex. Acad. Sci. 28:100-102. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, PREDATOR, PARASITES The city of Nacogdoches, after purchasing 140 acres of land, donated the land to the State of Texas for the site of the Stephen F. Austin State Teachers College. The ensuing years saw several of the large pines die from a variety of causes. It was thought that the culprit was the southern pine beetle, but there was little evidence to support this. During the summer months, pine trees died in groups of six to ten, indicating that the southern pine beetle may be at fault. However, when the trees were felled after several weeks, any evidence of a southern pine beetle attack was destroyed by secondary insects.

1020. **USDA FOREST SERVICE.** 1946. Anniversary report 1921-1946. USDA For. Serv. Southeast. For. Exp. Stn. p. 32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST RESISTANCE Data were taken on growth, resin density and susceptibility of pines to attack following attempts to enduce bark beetle attacks.

1021. **USDA FOREST SERVICE.** 1951. Bureau of entomology and plant quarantine. Southern pine beetle. Thirtieth Annu. Rep., 1950, USDA For. Serv. South. For. Exp. Stn. p. 65-68. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, IMPACT Southern pine beetles were epidemic in 1950. In East Texas over 32 million board feet of pine was killed in 1950. BHC was used as an insecticidal spray.

1022. **USDA FOREST SERVICE.** 1952a. Bureau of entomology and plant quarantine. Southern pine beetle. Thirty-first Annu. Rep., 1951, USDA For. Serv. South. For. Exp. Stn. p. 77-81. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, IMPACT The southern pine beetle continued to be epidemic in East Texas in 1951. BHC was used as a chemical control. In 1950 and 1951, 45 million board feet of saw timber and 36,000 cords of pulpwood out of 55 million board feet and 55,000 cords, respectively, was salvaged.

1023. **USDA FOREST SERVICE.** 1952b. Forest insect conditions in the Southeast during 1951. Annu. Rep. 1951, USDA For. Serv. Southeast. For. Exp. Stn. p. 39. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Dendroctonus valens, Ips* spp.). CONTROL-CULTURAL, SURVEY AND DETECTION The southern pine beetle was severe in East Texas in 1950 and 1951. In North Carolina, 4,600 acres were infested. Salvage operations in 1951 removed 300,000 board feet of infested pine.

1024. **USDA FOREST SERVICE.** 1952c. Forest insect conditions in the Southeast during 1952. USDA For. Serv. Annu. Rep. 1952, Southeast. For. Exp. Stn. p. 35-38. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, IMPACT The southern pine beetle was on the decline.

1025. **USDA FOREST SERVICE.** 1953a. Bureau of entomology and plant quarantine. Southern pine beetle--epidemic in Mississippi, dies out in Texas. Annu. Rep., 1952, USDA For. Serv. South. For. Exp. Stn. p. 87-88. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, IMPACT, CONTROL-CULTURAL The southern pine beetle was epidemic in Mississippi and declined in Texas. The outbreak in Mississippi was related to select damage. Mature beetle broods were destroyed at mills by burning infested slabs.

1026. **USDA FOREST SERVICE.** 1953b. Forest insect conditions, Alabama, Arkansas, Louisiana, Mississippi, Oklahoma, Texas. USDA For. Insect. Lab., Gulfport Miss., South. For. Exp. Stn. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp.). IMPACT Beetle activity in the East Texas epidemic (1950-1952) and in southwest Mississippi (1952-1953) had declined to endemic status in 1953. Salvage operations were effective in all areas.

1027. **USDA FOREST SERVICE.** 1954a. Forest insect research. Annu. Rep. 1953, USDA For. Serv. Southeast. For. Exp. Stn. Stn. Pap. No. 34. p. 48-49. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT The southern pine beetle was increasing in western North Carolina and eastern Tennessee.

1028. **USDA FOREST SERVICE.** 1954b. Forest insects. USDA For. Serv. South. For. Exp. Stn. South. For. Insect and Dis. Rep. No. 4, New Orleans, La. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION A serious southern pine beetle outbreak continued in northern Alabama. In southwest Mississippi, salvage and chemical control was continuing.

1029. **USDA FOREST SERVICE.** 1954c. Insects affecting forest trees. USDA For. Serv. South. For. Exp. Stn. Annu. Rep. 1954. p. 66-67. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus*

frontalis). SURVEY AND DETECTION The southern pine beetle was at infestation levels in eastern Texas, Alabama, and southwestern Mississippi. Infestations were greatest in heavily stocked stands.

1030. **USDA FOREST SERVICE.** 1954d. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Insect and Dis. Rep., New Orleans, La., No. 1. 3 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION A southern pine beetle outbreak was reported in Alabama (12,000 acres)--no activity in Mississippi or Texas.

1031. **USDA FOREST SERVICE.** 1954e. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Insect and Dis. Rep., New Orleans, La., No. 3. 3 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-GENERAL, CONTROL-CULTURAL, SURVEY AND DETECTION Southern pine beetle outbreaks were present in northern Alabama and Mississippi.

1032. **USDA FOREST SERVICE.** 1954f. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Insect and Dis. Rep., New Orleans, La., No. 5. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Scattered outbreaks of southern pine beetle occurred in Mississippi. In Alabama, prolonged warm weather favored late-season beetle activity.

1033. **USDA FOREST SERVICE.** 1954g. Southern pine beetle. USDA For. Serv. Southeast. For. Exp. Stn. Annu. Rep. 1953, Asheville, N. C. p. 49. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT A report on southern pine beetle population levels in the Southeast in 1953. Infestations were reported in North Carolina and eastern Tennessee.

1034. **USDA FOREST SERVICE.** 1955a. Forest insect research. Annu. Rep., 1954, USDA For. Serv. Southeast. For. Exp. Stn. Pap. No. 50, Asheville, N. C. p. 70-73. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). LIFE HISTORY-GENERAL, CONTROL-CHEMICAL, CONTROL-CULTURAL, CONTROL-LEGAL, SURVEY AND DETECTION, IMPACT Heavy losses were attributed to the southern pine beetle in North Carolina, Tennessee, and Virginia. About 20% of the timber was salvaged. Aerial surveys were conducted in January and June. Under the Forest Pest Control Act, 25,000 trees were chemically treated in North Carolina. A generalized life history of the southern pine beetle was diagrammed.

1035. **USDA FOREST SERVICE.** 1955b. Forest insect research. USDA For. Serv. Southeast. For. Exp. Stn. Annu. Rep. 1954; 1955. p. 70-73. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CHEMICAL, SURVEY AND DETECTION Southern pine beetle losses were heavy in North Carolina, Tennessee, and Virginia. Nearly 20% of the material was salvaged. Nearly 25,000 trees were treated with BHC southwide. The life cycle of the southern pine beetle is illustrated.

1036. **USDA FOREST SERVICE.** 1955c. Forest insects. USDA For. Serv. South. For. Exp. Stn. Annu. Rep. 1955. p.49-50. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle was epidemic in northern Alabama.

1037. **USDA FOREST SERVICE.** 1955d. Forest insects. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep. No. 7, New Orleans, La. 4p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle outbreak continued in northern Alabama.

1038. **USDA FOREST SERVICE.** 1955e. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 8. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Aerial flights were made over Texas, Arkansas, Louisiana, Mississippi, and Alabama. South Arkansas and south Alabama showed some pine mortality. There was reduced activity in southwest Mississippi.

1039. **USDA FOREST SERVICE.** 1955f. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 9. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION No noticeable outbreaks of southern pine beetle were found.

1040. **USDA FOREST SERVICE.** 1955g. Summary of insect conditions in 1954. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 6. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION Outbreaks occurred on the Talladega National Forest in Alabama. Chemical and salvage operations continued.

1041. **USDA FOREST SERVICE.** 1956a. Forest insect research. Annu. Rep. 1955, USDA For. Serv. Southeast. For. Exp. Stn., Asheville, N.C., p. 71-73. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CHEMICAL, SURVEY AND DETECTION In 1955, nearly 75,000 pines were treated with BHC. The residual control effectiveness of a 0.5% water emulsion of BHC was tested on the southern pine beetle. The emulsion killed 50% of the beetles after four weeks.

1042. **USDA FOREST SERVICE.** 1956b. Forest insects. Annu. Rep., 1955, USDA For. Serv. South. For. Exp. Stn. p. 49-50. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT The southern pine beetle was active in Alabama and Mississippi.

1043. **USDA FOREST SERVICE.** 1956c. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 11. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle was located for the first time in several years in East Texas. No other outbreaks were reported.

1044. **USDA FOREST SERVICE.** 1956d. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 12. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Localized infestations appeared in Alabama and Mississippi.

1045. **USDA FOREST SERVICE.** 1956e. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 13. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Very minor outbreaks occurred in Alabama.

1046. **USDA FOREST SERVICE.** 1957a. Forest insects. Annu. Rep., 1956, USDA For. Serv. South. For. Exp. Stn. p. 62-68. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, IMPACT Southern pine beetles were active in localized spots in East Texas, Alabama, and Mississippi.

1047. **USDA FOREST SERVICE.** 1957b. Forest insects. USDA For. Serv. Southeast. For. Exp. Stn. Annu. Rep. 1956, Asheville, N. C. p. 39-40. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CHEMICAL, SURVEY AND DETECTION Approximately six million board feet of pines were killed in 1956 in the southern Appalachians. About 40% of this volume was salvaged. A total of 63,368 trees were treated with BHC.

1048. **USDA FOREST SERVICE.** 1957c. Southern pine beetle increasing in Mississippi and Alabama. Southern pine beetle checked in Louisiana and Texas. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 16. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION An estimated 140 small spots of dead and dying

timber were aerially detected in Mississippi; many of these spots may have had southern pine beetle. There were localized spots in Texas and Louisiana.

1049. **USDA FOREST SERVICE.** 1957d. Southern pine beetle returns to East Texas. Southern pine beetle in Louisiana. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 15. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Two localized outbreaks were spotted in southeast Texas. For the first time in 40 years, the southern pine beetle was discovered killing timber in Louisiana.

1050. **USDA FOREST SERVICE.** 1957e. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 14. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION No outbreaks were reported; only single-tree attacks were detected.

1051. **USDA FOREST SERVICE.** 1957f. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 17. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION There were 140 small spots of dead timber detected in southwestern Mississippi; controls, including felling and spraying BHC, were put into effect. There was increased southern pine beetle activity in Alabama and incipient activity in the Big Thicket in southeastern Texas.

1052. **USDA FOREST SERVICE.** 1958a. Effect of low temperature on the southern pine beetle. USDA Southeast. For. Insect and Disease Newsletter 5:1-2. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Low temperatures reduced southern pine beetle populations.

1053. **USDA FOREST SERVICE.** 1958b. Forest insects. Annu. Rep., 1957, USDA For. Serv. South. For. Exp. Stn. p. 5-9 . (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT Southern pine beetle increased in southwestern Mississippi in 1957. The first record of southern pine beetle in Louisiana in 40 years was reported. Aerial surveys followed by ground checks were discussed.

1054. **USDA FOREST SERVICE.** 1958c. Forest insects. Annu. Rep., 1957, USDA For. Serv. Southeast. For. Exp. Stn., Asheville, N.C. p. 43-46. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, IMPACT, HAZARD/RISK RATING A program was proposed for southern pine beetle research to look at causes predisposing a stand to beetle attack. Stand density in attacked stands was very high compared to the site index. Attacks were in stands with greater than 75% pine in stands from 30 to 70 years of age. Beetle attacks were also forced on pine bolts. Outbreaks continued throughout the southern Appalachians. Over 33,000 trees were treated with BHC.

1055. **USDA FOREST SERVICE.** 1958d. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 22. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION A southern pine beetle outbreak developed rapidly in the Big Thicket area of southeast Texas. Southern pine beetle populations were low in Alabama and Mississippi.

1056. **USDA FOREST SERVICE.** 1958e. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 23. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle outbreak in the Big Thicket of southeast Texas covered approximately 65,000 acres. The Texas Forest Service assumed leadership in the overall control program. The southern pine beetle increased activity in Alabama, Mississippi, and Louisiana.

1057. **USDA FOREST SERVICE.** 1958f. Summary of midsouth pest conditions in 1957. Forest insects. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep. No. 20, New Orleans, La. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Reviews the 1957 outbreak in Louisiana and the 1952-1954 outbreaks in Mississippi. In Texas and Alabama, increasing bark beetle activity occurred.

1058. **USDA FOREST SERVICE.** 1958g. This is Alice Frontalis. Your dying pines may have met her. USDA For. Serv. PA-294. 22 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-CHEMICAL A layman's guide to the detection and control of the southern pine beetle. The guide is in a booklet format with large print and cartoon illustrations.

1059. **USDA FOREST SERVICE.** 1959a. Forest insects. Annu. Rep., 1958, USDA For. Serv. Southeast. For. Exp. Stn. p. 43-44. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans,*). SURVEY AND DETECTION, IMPACT, WEATHER RELATIONSHIPS Subzero winter temperatures reduced southern pine beetle populations by 95% to 100%. Populations of clerids were reduced by 40%. Chemical treatment programs were halted.

1060. **USDA FOREST SERVICE.** 1959b. Forest insects. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 26. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle increased activity in East Texas. One localized infestation occurred in Louisiana.

1061. **USDA FOREST SERVICE.** 1959c. Forest insects. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 27. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle activity continued in East Texas.

1062. **USDA FOREST SERVICE.** 1959d. Summary of midsouth pest conditions in 1958. Forest insects. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep. No. 25, New Orleans, La. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Only localized activity occurred in early 1959.

1063. **USDA FOREST SERVICE.** 1960a. Forest insects. Annu. Rep., 1959, USDA For. Serv. Southeast. For. Exp. Stn. p. 72-78. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, IMPACT Southern pine beetle populations were very low due to subzero temperatures in 1958.

1064. **USDA FOREST SERVICE.** 1960b. Forest insects. 1959 at the South. For. Exp. Stn. USDA For. Serv. p. 41,47-48. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION, IMPACT During 1959, a southern pine beetle outbreak developed rapidly in the Big Thicket of East Texas. The Texas Forest Service controlled spots by felling and treating infested trees with benzene hexachloride in fuel oil. One hundred and forty-four spot infestations were reported on 70,000 acres in Texas. The southern pine beetle was at static population levels throughout the rest of the southern United States.

1065. **USDA FOREST SERVICE.** 1960c. Forest insects. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 31. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, IMPACT The southern pine beetle outbreak continued in East Texas. An estimated 10 million board feet of sawtimber and 30,000 cords of pulpwood were killed.

1066. **USDA FOREST SERVICE.** 1960d. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 30. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus*

terebrans, Ips spp.). SURVEY AND DETECTION The southern pine beetle continued to increase in activity in East Texas.

1067. **USDA FOREST SERVICE.** 1960e. Summary of midsouth pest conditions in 1959. Forest insects. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep. No. 29, New Orleans, La. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION During the early summer, a southern pine beetle outbreak of 70,000 acres occurred in the Big Thicket of East Texas.

1068. **USDA FOREST SERVICE.** 1961a. Forest insects. Annu. Rep., 1960, USDA For. Serv. Southeast. For. Exp. Stn. p. 39-42. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT Southern pine beetle populations were moderate to low south wide.

1069. **USDA FOREST SERVICE.** 1961b. Forest insects. 1960 at the South. For. Exp. Stn. USDA For. Serv. p. 44-46. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT The southern pine beetle declined in East Texas. Southern pine beetle populations increased in trees infected by *Ips avulsus*.

1070. **USDA FOREST SERVICE.** 1961c. Forest insects. Pine bark beetles. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 32. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Describes the outbreak in southeast Texas where an estimated 10 million board feet of sawtimber and 30,000 cords of pulpwood were destroyed.

1071. **USDA FOREST SERVICE.** 1961d. Southern pine beetle. USDA For. Serv. South. For. Exp. Stn. South. For. Pest Rep., New Orleans, La. No. 33. 5 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle outbreak in East Texas continued.

1072. **USDA FOREST SERVICE.** 1962a. Forest insects. 1961 at the South. For. Exp. Stn. USDA For. Serv. p. 43-44. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT, COMPETITION, CONTROL-CHEMICAL, SAMPLING, PREDATOR Southern pine beetle outbreaks continued in East Texas in 1961. Spots were controlled with BHC. In trees attacked simultaneously by *Ips avulsus* and southern pine beetle, survival of southern pine beetle was poor. Sampling trees at 16 feet in height gave the most dependable data. Since clerids emerge after bark beetles have emerged, BHC should not be applied to these trees. Southern pine beetle populations increased in Mississippi and Alabama.

1073. **USDA FOREST SERVICE.** 1962b. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. For. Pest Rep. No. 3, Atlanta, Ga. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION In Texas the outbreak area was estimated at 4.5 million acres, with 20,000 acres of timber killed; the southern pine beetle was on a downward trend by July. The southern pine beetle was epidemic in northern Georgia and the upper Piedmont of South Carolina. Low beetle activity occurred in Alabama and Mississippi.

1074. **USDA FOREST SERVICE.** 1962c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 1, Atlanta, Ga. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle ravaged pine stands in the Big Thicket area of Texas and reached epidemic levels in Alabama, Mississippi, South Carolina, and Georgia.

1075. **USDA FOREST SERVICE.** 1962d. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 2, Atlanta, Ga. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION High losses from the southern pine beetle continued. In East Texas, the current infestation covers approximately two million acres in the Big Thicket area. The southern pine beetle remained epidemic in northeast Georgia and western South Carolina.

1076. **USDA FOREST SERVICE.** 1962e. Status of insects. USDA For. Serv. For. Insect Conditions in the U. S. 1962. p. 23. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, REVIEW Southern pine beetle populations were at epidemic levels in Texas, Georgia, North Carolina, South Carolina, Mississippi and Alabama in 1962. Populations showed some signs of decline in the latter part of the summer and through the fall.

1077. **USDA FOREST SERVICE.** 1963a. Forest insects. 1962 at the South. For. Exp. Stn. USDA For. Serv. p. 34-37. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT, MITES Southern pine beetle was distributed over 600,000 acres in East Texas in 1962. Predacious mites became abundant.

1078. **USDA FOREST SERVICE.** 1963b. Forest insects. 1962 at the Southeast. For. Exp. Stn. USDA For. Serv. p. 56-60. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT, RADIOGRAPHY Southern pine beetles were epidemic in the Upper Piedmont of Georgia. Over one million trees were killed. Radiographs were found to be as accurate as dissection for counting brood.

1079. **USDA FOREST SERVICE.** 1963c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. For. Pest Rep. No. 2, Atlanta, Ga. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, CONTROL-CULTURAL Southern pine beetle activity continued in Texas, Alabama, and Mississippi at reduced levels. Over 800,000 infested trees were removed in Georgia by Georgia Forestry Commission crews.

1080. **USDA FOREST SERVICE.** 1963d. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. For. Pest Rep. No. 3, Atlanta, Ga. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Overall activity declined from the previous year. In Texas, the most active area was Orange County.

1081. **USDA FOREST SERVICE.** 1963e. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. Reg. South. For. Pest Rep. No. 4, Atlanta, Ga. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle declined from a major epidemic in 1962 to localized outbreaks in a seven state area in 1963. The first southern pine beetle outbreak since 1957 occurred in Louisiana.

1082. **USDA FOREST SERVICE.** 1963f. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis*, Zimm. USDA For. Serv. South. For. Pest Rep. No. 1, Atlanta, Ga. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle activity was generally increasing southwide. Outbreaks were reported in southern Texas, Alabama, Georgia, and North and South Carolina.

1083. **USDA FOREST SERVICE.** 1964a. Forest insects. 1963 at the South. For. Exp. Stn. USDA For. Serv. p. 42-45. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, IMPACT, MITES, PREDATOR, OUTBREAKS Southern pine beetle decreased in East Texas in 1963. Predacious mites were very abundant. Southern pine beetle outbreaks were on poorly drained soils.

1084. **USDA FOREST SERVICE.** 1964b. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. Reg. South. For. Pest Rep. No. 1, Atlanta, Ga.

7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle continued to decline over the southern United States.

1085. **USDA FOREST SERVICE.** 1964c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. Reg. South. For. Pest Rep. No. 2, Atlanta, Ga. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle activity increased in Louisiana, Mississippi, and Texas.

1086. **USDA FOREST SERVICE.** 1964d. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. Reg. South. For. Pest Rep. No. 3, Atlanta, Ga. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Epidemic outbreaks of the southern pine beetle occurred in the Piedmont area of North Carolina, parts of the Talledega National Forest in Alabama, and in Mississippi and South Carolina.

1087. **USDA FOREST SERVICE.** 1965a. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. Reg. South. For. Pest Rep. No. 1, Atlanta, Ga. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION New epidemics occurred in Tennessee, Hall County, Georgia, in Granville County, North Carolina, and the north Piedmont of North Carolina.

1088. **USDA FOREST SERVICE.** 1965b. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. Reg. South. For. Pest Rep. No. 2, Atlanta, Ga. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Epidemics of the southern pine beetle continued in Alabama, Louisiana, Mississippi, North and South Carolina, Tennessee, and Texas.

1089. **USDA FOREST SERVICE.** 1965c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. Reg. South. For. Pest Rep. No. 3, Atlanta, Ga. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION Outbreaks of the southern pine beetle continued southwide. Chemical and salvage control programs continued.

1090. **USDA FOREST SERVICE.** 1966a. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. South. Reg. South. For. Pest Rep. No. 1, Atlanta, Ga. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, CONTROL-CHEMICAL, CONTROL-CULTURAL, MAPS Epidemics of the southern pine beetle continued in Alabama, Mississippi, North Carolina, and Tennessee. Controls by chemicals and salvage continued. An infestation map is included.

1091. **USDA FOREST SERVICE.** 1966b. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 2, Atlanta, Ga. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, WEATHER RELATIONSHIPS Cold temperatures apparently caused southern pine beetle populations to decline in Alabama, Georgia, and Tennessee. Increases in beetle populations occurred in Louisiana, Mississippi, Texas, and the coastal area of South Carolina.

1092. **USDA FOREST SERVICE.** 1966c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 3, Atlanta, Ga. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle epidemics continued in South Carolina, Mississippi, and Texas.

1093. **USDA FOREST SERVICE.** 1967a. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 1, Atlanta, Ga. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle populations continued throughout the southeastern United States.

1094. **USDA FOREST SERVICE.** 1967b. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 2, Atlanta, Ga. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Epidemics of the southern pine beetle were confined to the southeastern parts of Texas, and parts of Louisiana. Losses were expected to exceed those from the last few years of outbreak.

1095. **USDA FOREST SERVICE.** 1967c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 3, Atlanta, Ga. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, MAPS Southern pine beetle populations were at their highest level of recorded activity throughout the southeastern area. An infestation map is included.

1096. **USDA FOREST SERVICE.** 1968a. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 1, Atlanta, Ga. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, MAPS Overwintering southern pine beetle populations continued at a high level throughout the southeastern area. The outbreak in central Louisiana is mapped.

1097. **USDA FOREST SERVICE.** 1968b. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 2, Atlanta, Ga. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle infestations continued southwide.

1098. **USDA FOREST SERVICE.** 1968c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 3, Atlanta, Ga. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp. CLERIDAE, *Thanasimus* sp.). SURVEY AND DETECTION, CONTROL-CULTURAL, RADIOGRAPHY Southern pine beetle infestations continued in South Carolina, Texas, Louisiana, and the coastal region of North Carolina. Control crews emphasized salvage of infested material. Radiography of bark discs was included.

1099. **USDA FOREST SERVICE.** 1969a. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 1, Atlanta, Ga. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). PREDATOR, VERTEBRATES, CONTROL-CULTURAL, SURVEY AND DETECTION, RADIOGRAPHY, IMPACT Southern pine beetle infestations are occurring southwide. Control crews are emphasizing removal of infested material through commercial sales. The southern pine beetle outbreak in Texas is the worst since 1962. Intensive salvage occurred in that state. Radiographs of bark showed predation by woodpeckers.

1100. **USDA FOREST SERVICE.** 1969b. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 2, Atlanta, Ga. 11 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, CONTROL-CULTURAL The southern pine beetle infestation covered six million acres in East Texas. Localized outbreaks occurred in

Arkansas for the first time since the early 1900's. Control emphasis was placed on rapid removal of infested trees by commercial sales.

1101. **USDA FOREST SERVICE.** 1969c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 3, Atlanta, Ga. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle infestations declined in East Texas compared to 1968 levels. Southern pine beetle infestations continued at high levels in Alabama and the Piedmont regions of North and South Carolina.

1102. **USDA FOREST SERVICE.** 1970a. Detection of forest pests in the southeast. USDA For. Serv. State and Priv. For. Southeast. Area Div. For. Pest Control. 51 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Forest pests are related to stand conditions in the southeastern United States.

1103. **USDA FOREST SERVICE.** 1970b. Evaluating southern pine beetle infestations. USDA For. Serv. State and Priv. For. Serv. Southeast. Area Div. For. Pest Control. 36 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, RADIOGRAPHY, STAND CONDITIONS Aerial, ground detection, and laboratory evaluations summarized for the southern pine beetle. Radiographic sampling is discussed.

1104. **USDA FOREST SERVICE.** 1970c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 1, Atlanta, Ga. 10 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The southern pine beetle increased in activity southwide.

1105. **USDA FOREST SERVICE.** 1970d. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 2, Atlanta, Ga. 12 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION The cold spell in Alabama, North Carolina, Tennessee, and Virginia killed 95-97% of the southern pine beetle brood. Southern pine beetle activity is reported in other parts of the Southeast.

1106. **USDA FOREST SERVICE.** 1970e. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 3, Atlanta, Ga. 13 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, WEATHER RELATIONSHIPS Preliminary investigations indicated substantial brood reduction due to cold weather in January in northern Alabama, North Carolina, and Tennessee. Southern pine beetle declined in Texas below levels of recent years. Photographs of southern pine beetle mortality were included.

1107. **USDA FOREST SERVICE.** 1971a. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area For. Pest Manage. South. For. Pest Rep. No. 2, Atlanta, Ga. 13 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle infestations were at low levels in the Southeast.

1108. **USDA FOREST SERVICE.** 1971b. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area For. Pest Manage. South. For. Pest Rep. No. 3, Atlanta, Ga. 21 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle populations increased over the southeastern area.

1109. **USDA FOREST SERVICE.** 1971c. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area South. For. Pest Rep. No. 1, Atlanta, Ga. 14 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle populations increased southwide. Beetle populations collasped in South Carolina and were reported at low levels in Texas, Louisiana, and Mississippi.

1110 **USDA FOREST SERVICE.** 1971d. Status of insects. USDA For. Serv. For. Insect and Dis. Conditions in the U. S. 1971, p. 45-46. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION A tremendous increase in southern pine beetle populations was noted in most areas of the South and Southeast in 1971.

1111. **USDA FOREST SERVICE.** 1972a. Southern and Southeastern States (R-8). USDA For. Serv. For. Insect and Dis. Conditions in the U. S. 1972. p. 44-47,58,65. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp. CURCULIONIDAE; *Hylobius pales*). IMPACT, MAPS In 1972, the southern pine beetle outbreak involved 60.9 million acres in the southeastern United States. In Georgia, the outbreak covered nine million acres with the Atlantic Urban area severely affected. In North Carolina, the outbreak covered 6.7 million acres. Beetle activity increased in South Carolina, the Piedmont area of Virginia, and increased dramatically in Alabama where over 23 million board feet of pine timber was infected. Southern pine beetle activity also increased in Louisiana, southern Arkansas, and Mississippi. Over eight million acres were infected in East Texas. A distribution map is included.

1112. **USDA FOREST SERVICE.** 1972b. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area For. Pest Manage. South. For. Pest Rep. Atlanta, Ga. 19 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CHEMICAL, CONTROL-CULTURAL, SURVEY AND DETECTION The southeastern area experienced a dramatic southern pine beetle explosion. Current suppression procedures recommended by the Forest Service are included. These include: 1) removal of infested trees by commercial sale, 2) piling and burning, and 3) chemical control. The southern pine beetle outbreak area is diagrammed. Pitch tubes and galleries are pictured.

1113. **USDA FOREST SERVICE.** 1973a. Status of forest insects. Southern pine beetle, *Dendroctonus frontalis* Zimm. USDA For. Serv. State and Priv. For. Southeast. Area For. Pest Manage. South. For. Pest Rep. Atlanta, Ga. 17 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). CONTROL-CULTURAL, SURVEY AND DETECTION Southern pine beetle populations remained moderate to high with expanding outbreaks occurring in areas already infested. The mild winter probably did not adversely affect southern pine beetle populations. Suppression efforts included 195,351 cords and 108.4 million board feet of timber salvaged. A map of the infestations as of 1973 was included.

1114. **USDA FOREST SERVICE.** 1973b. Status of insects. USDA For. Serv. For. Insect and Dis. Conditions in the U. S. 1973. p. 36-39. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION Southern pine beetle infestations are described for the southeastern United States. Infestations were greatest in Alabama, East Texas, and North and South Carolina. Southern pine beetle infestations were moderate to light in other southern States.

1115. **USDA FOREST SERVICE.** 1974a. Southeastern area southern pine beetle outbreak status, July 1974. Southeast. Area, State and Priv. For., USDA For. Serv., Atlanta, Ga. 11 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL, SURVEY AND DETECTION, REVIEW, IMPACT, MAPS Summarizes southern pine beetle outbreaks throughout the southern United States. Tables are given for acreages of susceptible host type, salvage operations, and monetary expense for losses and control. Included is a map

of southern pine beetle outbreaks from 1971-1974.

1116. **USDA FOREST SERVICE.** 1974b. Status of insects. USDA For. Serv. Insect and Dis. Conditions in the U. S. 1974. p. 39-40. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus terebrans*, *Ips* spp.). SURVEY AND DETECTION, MAPS The southern pine beetle was the primary pest in the region. The southern pine beetle was epidemic in Florida, the Piedmont and northwest sections of Alabama, central Louisiana, southwestern Mississippi, North and South Carolina, eastern Tennessee, northern Georgia, central Virginia, and East Texas. Salvage logging by the State Forestry Commission continued southwide. The Georgia Forestry Commission chemically treated 61,000 trees in 1974.

1117. **USDA FOREST SERVICE.** 1975a. Southeastern area southern pine beetle outbreak status. USDA For. Serv. State and Priv. For. 11 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, ECONOMICS, IMPACT Maps of southern pine beetle outbreaks are presented along with losses in 1975 in the Southeast.

1118. **USDA FOREST SERVICE.** 1975b. Status of insects. USDA For. Serv. For. Insect and Disease Conditions in the U. S. 1975. p. 41-43. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, ECONOMICS, OUTBREAKS A report of the status of southern pine beetle populations and outbreaks in the Southeast in 1975.

1119. **USDA FOREST SERVICE.** 1977. Expanded Southern Pine Beetle Research and Applications Program. USDA South. Pine Beetle Action Counc. 7 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL This pamphlet describes the objectives, structure, and functions of the Expanded southern pine beetle Research and Applications Program.

1120. **USDA FOREST SERVICE.** 1978. What we know to date in the Expanded Southern Pine Beetle Research and Applications Program. USDA South. Pine Beetle Res. and Appl. Program, Pineville, La. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW A review of the southern pine beetle control program in 1978 is presented, including survey techniques, infestation status, economic thresholds, and recommended control and preventative measures.

1121. **USDA FOREST SERVICE.** 1979a. Southern pine beetle fact sheet number 1: Use of beetle-killed timber for lumber. USDA For. Serv. For. Bull. SH-FB-P 14. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION The use of beetle-killed timber for lumber is discussed, along with associated problems and points to consider in such usage.

1122. **USDA FOREST SERVICE.** 1979b. Southern pine beetle fact sheet number 3: Setting control priorities for the southern pine beetle. USDA For. Serv. For. Bull. SH-FB P. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, HAZARD/RISK RATING Guidelines are presented to aid the forester in classifying infested trees and establishing southern pine beetle control priorities.

1123. **USDA FOREST SERVICE.** 1979c. Southern pine beetle fact sheet number 5: Insecticides for the southern pine beetle. USDA For. Serv. For. Bull. SH-FB P18. 1 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL The use of lindane and Dursban for southern pine beetle control is discussed.

1124. **USDA FOREST SERVICE.** 1979d. Southern pine beetle technology transfer task force report. USDA For. Serv. Tech. Publ. SA-TP-7. 23 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, ECONOMICS, IMPACT, REVIEW A southern pine beetle task force report included the development of an information system for populations dynamics, control measures, economic impact, silvicultural relationships, wood utilization, behavioral chemicals, and technology transfer.

1125. **USDA FOREST SERVICE.** 1979e. Southern pine beetle fact sheet number 2: Use of beetle-killed timber for pulp, plywood and paneling. USDA For. Serv. For. Bull. SH-FB-P 15. 1 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT, WOOD UTILIZATION A discussion is presented on the use of beetle-killed timber for pulp, plywood and paneling.

1126. **USDA FOREST SERVICE.** 1980a. Southern pine beetle fact sheet number 8: FRONSIM, a computer program model. USDA For. Serv. For. Bull. SA-FB/P 20. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, MODELING A computer model that simulates the damage (physical and monetary) that southern pine beetle infestations may cause to large areas is explained in this fact sheet.

1127. **USDA FOREST SERVICE.** 1980b. Southeastern area southern pine beetle outbreak status October 1979-September 1980. USDA For. Serv. State and Priv. For. Southeast. Area For. Bull. SA-FB/P28. 8 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, STAND CONDITIONS Maps the southern pine beetle activity for October 1979 through September 1980. Areas of greatest activity were Georgia, Alabama, Mississippi, and South Carolina, although populations decreased in these areas. Tables are given for southern pine beetle status, suppression projects, outbreak intensity, and areas of susceptible host type by owner class.

1128. **USDA FOREST SERVICE.** 1980c. Southern pine beetle fact sheet number 13: Use of beetle-killed timber for particleboard and hardboard. USDA For. Serv. For. Bull. SA-FB/P 31. 1 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION The use of beetle-killed timber for particleboard and hardboard is discussed.

1129. **USDA FOREST SERVICE.** 1980d. Southern pine beetle fact sheet number 14: TBAP--Timber Benefits Analysis Program. USDA For. Serv. For. Bull. SA-FB/P 32. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT A computerized procedure (TBAP) for calculating monetary losses which result from insect attacks is described.

1130. **USDA FOREST SERVICE.** 1980e. Southern pine beetle fact sheet number 4. An aerial observer's guide to recognizing and reporting southern pine beetle spots. USDA For. Serv. For. Bull. SA-FB/P 17 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION Guides for assigning priorities for ground checking beetle spots are presented.

1131. **USDA FOREST SERVICE.** 1980f. Southern pine beetle fact sheet number 6: Woodpeckers can help control the southern pine beetle. USDA For. Serv. For. Bull. SA-FB/P 9. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, VERTEBRATES, CONTROL-BIOLOGICAL, INTEGRATED PEST MANAGEMENT The role and predatory activity of woodpeckers (hairy, downy, pileated, and red-bellied) in southern pine beetle control is discussed. Six forest management practices that would form an increase in woodpecker populations are described.

1132. **USDA FOREST SERVICE.** 1980g. Southern pine beetle fact sheet number 12: LORAN-C navigation. USDA For. Serv. For. Bull. SA-FB/P 30. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES The Loran-C radio navigation system is described as it is used in aerial spot detection and evaluation of southern pine beetle infestations.

1133. **USDA FOREST SERVICE.** 1981a. Evaluation of the Expanded Southern Pine Beetle Research and Applications Program. USDA Comb. For. Pest Res. and Dev. Prog. Res. Agreement No. OS-78-07. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). REVIEW, INTEGRATED PEST MANAGEMENT The ESPBRAP is evaluated.

1134. **USDA FOREST SERVICE.** 1981b. Southern pine beetle fact sheet number 15: Salvage removal. USDA For. Serv. For. Bull. SA-FB/P 33. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT Salvage removal of southern pine beetle-infested trees is discussed as a

control method.

1135. **USDA FOREST SERVICE.** 1981c. Southern pine beetle fact sheet number 17: Chemical control. USDA For. Serv. For. Bull. SA-FB/P 35. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CHEMICAL Chemical control of the southern pine beetle with insecticides is explained in this fact sheet.

1136. **USDA FOREST SERVICE.** 1981d. Southern pine beetle fact sheet number 18: Pile-and-burn. USDA For. Serv. For. Bull. SA-FB/P 36. 1 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL The felling, piling, and burning of southern pine beetle-infested trees as a control method is described in this fact sheet.

1137. **USDA FOREST SERVICE.** 1981e. Southern pine beetle fact sheet number 19. A method for assessing the impact of southern pine beetle damage on esthetics values. USDA For. Serv. For. Bull. SA-FB/P 37. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT, AESTHETICS The aesthetic impact of southern pine beetle on the timber resource is discussed.

1138. **USDA FOREST SERVICE.** 1981f. Southern pine beetle fact sheet number 23: DAMBUGS - A case study. USDA For. Serv. For. Pest Manage. For. Bull. SA-FB/P 42. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MODELING, IMPACT DAMBUGS is a simulation model using information on stand characteristics to project damage to timber over a large geographical area.

1139. **USDA FOREST SERVICE.** 1981g. Southern pine beetle program accomplishment report. USDA Comb. For. Pest Res. and Dev. Prog. Agric. Info. Bull. No. 438. 23 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, REVIEW, INTEGRATED PEST MANAGEMENT Outlines accomplishments for the Expanded Southern Pine Beetle Research Applications Program. Life history notes are followed by summaries of economic impact models, use of beetle-felled timber, benefits and costs of control tactics, beetle population sampling, models for population trends, aerial survey and navigation systems, stand hazard rating and cultural practices, chemical suppression, integrated pest management strategies, and technology transfer.

1140. **USDA FOREST SERVICE.** 1981h. Technology transfer applications plan for projects funded by the Integrated Pest Management Program. USDA South. For. Exp. Stn. State and Priv. For., Southeast. Area. 30 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). REVIEW, INTEGRATED PEST MANAGEMENT Provides synopses of funded projects for the Integrated Pest Management Program.

1141. **USDA FOREST SERVICE.** 1981i. Southern pine beetle fact sheet number 16: Cut-and-leave. USDA For. Serv. For. Bull. SA-FB/P 34. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL The cut-and-leave method to control the southern pine beetle is explained in this fact sheet.

1142. **USDA FOREST SERVICE.** 1982. Buffer strip. Southern pine beetle fact sheet number 24. USDA For. Serv. For. Pest Manage. For. Bull. SA-FB/P 43. 2 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL Buffer strips for use in cut-and-leave and salvage for control of southern pine beetle are diagrammed and discussed.

1143. **VALENTINE H. T.** 1981. Comment by Harry T. Valentine on "Stand and site conditions related to southern pine beetle susceptibility" by Ronald J. Kushmal, Michael D. Cain, Charles E. Rowell, and Richard L. Porterfield. For. Sci. 27:504. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STATISTICAL METHODS, HAZARD/RISK RATING Valentine contends that ranking stand susceptibility to southern pine beetle by dividing discriminant function analysis into categories may not be valid.

1144. **VAN SAMBEEK J. W.** 1978. Influence of fungal associates of the southern pine beetle on inner bark constituents of loblolly pine. Phytopathol. News (Abstr.) 12:184. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ceratocystis minor*). COMMENSALISM AND SYMBIOSIS, PUPAE Fungal extractives of *Ceratocystis minor* delayed development of *Dendroctonus frontalis* pupae.

1145. **VAN SAMBEEK J. W., KILE B. W.** 1981. Egg gallery excavation and brood production by reemerged and newly emerged females of *Dendroctonus frontalis* Zimm. J. Ga. Entomol. Soc. 16:345-352. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FECUNDITY Reemerged females, alone or with males, produced more egg niches per centimeter of gallery than recently mated brood females. Brood females without males excavated shorter galleries and laid fewer eggs per day.

1146. **VERRALL A. F.** 1941. Dissemination of fungi that stain logs and lumber. J. Agric. Res. 63:549-558. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). VECTOR Staining fungi are disseminated by means of air currents, insects, milling machinery, rain water, and transport of infected wood. The insects of the most practical importance as carriers of staining fungi are bark beetles and ambrosia beetles. Bark beetles inoculate pine logs and ambrosia beetles inoculate hardwood logs. More research is needed to aid in developing a cheap and effective means of repelling insects from logs and lumber in order to control stain.

1147. **VITÉ J. P.** 1968. Timber industry attacks bark beetle problem through basic research. Tex. Ind. Sept. 1968. 14-15,32. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-CHEMICAL Vite reviews the discovery and potential use of pheromones of *Dendroctonus frontalis*, including *trans*-verbenol from adult females and verbenone from adult males and also frontalin. The phenomenon of mass aggregation is elicited by a combination of host odors and insect pheromones.

1148. **VITÉ J. P.** 1970. Erste Anwendung synthetischer Populationslockstoffe in der Borkenkaferbekampfung. Allg. Forstzeitschrift 25:615-616. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus brevicomis, Dendroctonus pseudotsugae, Dendroctonus ponderosae*). BEHAVIORAL CHEMICALS, REVIEW Reviews research at Boyce Thompson Institute of Plant Research that led to the discovery of frontalin. The necessity for the pheromones to act in combination with host tree volatiles to ensure mass attack is emphasized.

1149. **VITÉ J. P.** 1971. Pest management systems using synthetic pheromones. Contrib. Boyce Thompson Inst. 24:343-350. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, CONTROL-CHEMICAL The use of combinations of pheromones and host terpenes in the manipulation and control of *Dendroctonus* bark beetles is discussed. Chemical release systems and the factors influencing response to attractants are discussed. *D. frontalis*, *D. brevicomis*, and *D. pseudotsugae* aggregate in response to a mixture of frontalin and an appropriate terpene, while *trans*-verbenol and *alpha*-pinene are used by *D. ponderosae*. Recommended control strategies depend on forestry practices and are designed to foster survival and increase of Clerid and Ostomid predators. The injection of cacodylic acid into harvestable trees serves to concentrate bark beetles. When attractant mixtures are selected which do not affect predators, sticky traps can be used.

1150. **VITÉ J. P.** 1971. Silviculture and the management of bark beetle pests. Proc. Tall Timbers Conf. on Ecol. Animal Control by Habitat Manage. 3:155-168. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). STAND CONDITIONS, CONTROL-CULTURAL The use of silviculture for management of bark beetle populations was summarized. Southern pine beetles were more prevalent in dense, overstocked pine stands.

1151. **VITÉ J. P.** 1974. Southern pine beetle pheromones and attractants. *In*, Southern Pine Beetle Symp., Payne T. L., Coulson R. N., Thatcher R. C., Eds., March 7-8, 1974. Tex.

Agric. Exp. Stn., College Station, Tex. p. 35-38. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus mexicanus*, *Dendroctonus arizonicus*). DISTRIBUTION, SEX-RATIOS, BEHAVIORAL CHEMICALS, TAXONOMY Based on behavioral responses, Vite identified three distinct southern pine beetle populations; these were a population on *Pinus leiophylla* in central Mexico described as *Dendroctonus mexicanus*. Gas chromatography show both sexes with *trans*-verbenol. Emergent males also contain verbenone, myrtenol, borneol, and *iso*-borneol. A population in *P. tenuifolia* in Guatemala contained an unidentified compound. A population in the *P. oocarpa* region of Honduras that was *D. frontalis* or a closely related species, had large quantities of *endo*-brevicomin. Vite outlines the proposed mechanism of initial attack, mass attack, and shifting of attack for the southern pine beetle; he proposes the incorporation of pheromones into bark beeetle management systems.

1152. **VITÉ J. P.** 1975. Moglichkeiten und Grenzen der Pheromonanwendung in der Borkenkaferbekampfung. (Possibilities and limits in the application of pheromones in bark beetle control.). Z. Angew. Entomol. 77:325-329. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, ATTRACTANTS, REVIEW Possibilities and limits of using synthetic pheromones in bark beetle management are disussed. A successful point-application of synthetic pheromones in bark beetle management depends on the timely removal of baited trees if trap trees are used. The direct application to the host trees is complemented by the natural aggregation stimuli as the baited tree becomes infested, and moreover, does not decimate ambulant insect predators. 'Trap-out' techniques are limited for several reasons. The area application of pheromones, both attractant and inhibitory or their combination, holds promise for a simple and more effective application since many bark beetle species must aggregate before a host tree can be colonized successfully.

1153. **VITÉ J. P.** 1976. The fundamental bases for Integrated Pest Management: Ecosystem interactions. XVI IUFRO World Congr. Proc.-Div. II. p. 395-405. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus ponderosae*, *Dendroctonus brevicomis*, *Ips typographus*, *Blastophagus piniperda*, *Scolytus scolytus*, *Scolytus multistriatus*). ECOLOGICAL DISTRIBUTION, BEHAVIORAL CHEMICALS, REVIEW, INTEGRATED PEST MANAGEMENT Vite uses simplified biological models and examples to illustrate intrinsic and extrinsic factors for bark beetle interactions in the ecosystem. *Dendroctonus frontalis* is used as an example of mass attack keyed by host volatiles and bark beetle pheromones.

1154. **VITÉ J. P., COSTER J. E.** 1973. The use of sticky traps in survey and control of the southern pine beetle, *Dendroctonus frontalis*. Folia. Entomol. Mex. 25:53. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, TRAPS AND CAGES, MISCELLANEOUS TECHNIQUES The potential use of sticky traps, baited with frontalure, for survey and control of *Dendroctonus frontalis* is discussed.

1155. **VITÉ J. P., CROZIER R. G.** 1968. Studies on the attack behavior of the southern pine beetle. IV. Influence of host condition on aggregation pattern. Contrib. Boyce Thompson Inst. 24:87-93. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, HOST SELECTION, HOST RESISTANCE The condition of the host exerts a strong influence on the aggregation behavior of *Dendroctonus frontalis*. Large tree stumps and large log sections are preferred to smaller ones. These rapidly lose their attractiveness to the beetle population in flight as they dry out. Loss of attractiveness was found to coincide with the beginning of extensive feeding in suitable host tissue. Sex-specific volatiles were depleted as feeding progressed. The physiological condition of the host material apparently determines the rate of feeding which in turn affects production and release of the attractant.

1156. **VITÉ J. P., FRANCKE W.** 1976. The aggregation pheromones of bark beetles: Progress and problems. Naturwissenschaften 63:550-555. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS The influence of host-plant odors, pheromones and kairomones on the colonization of trees by bark beetles is examined. Chemical considerations and the biosynthesis of bark-beetle pheromones are discussed. Pheromone specificity, primary and secondary attraction, as well as kairomones, are examined in different bark beetle species. Synthetic pheromones may be applied in two ways–as a spot application or as an area application. Methodology and limitations of pheromone application are discussed.

1157. **VITÉ J. P., GARA R. I.** 1961. A field method for observation on olfactory responses of bark beetles (Scolytidae) to volatile materials. Contrib. Boyce Thompson Inst. 21:175-182. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). ATTRACTANTS, TRAPS AND CAGES Describes different methods of field testing scolytid produced attractants. Rotary nets were the most effective.

1158. **VITÉ J. P., GARA R. I., VON SCHELLER H. D.** 1964. Field observations on the response to attractants of bark beetles infesting southern pines. Contrib. Boyce Thompson Inst. 22:461-470. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp., *Ips* spp.). PREDATOR, PARASITES, BEHAVIORAL CHEMICALS, ATTRACTANTS, FLIGHT Diurnal patterns of response by the southern pine beetle and the three principal southern *Ips* species (*I. avulsus*, *I. calligraphus* and *I. grandicollis*) to southern pine bolts infested by various bark beetle species were studied. Patterns of response by predators and other bark beetle associations were also studied, as well as the correlation of these patterns to weather variables.

1159. **VITÉ J. P., HUGHES P. R., RENWICK J. A. A.** 1976. Southern pine beetle: Effect of aerial pheromone saturation on orientation. Naturwissenschaften 63:44. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS Aerial applications of frontalure did not disrupt the aggregation and attack of *Dendroctonus frontalis* on loblolly pines. Instead, aerial saturation with the pheromone in a heavily beetle-infested pine forest resulted in a rapid increase in the aggregation of beetles on pine trees undergoing attack.

1160. **VITÉ J. P., ISLAS S. F., RENWICK J. A. A., HUGHES P. R., KLIEFOTH R. A.** 1974. Biochemical and biological variation of southern pine beetle populations in North and Central America. Z. Angew. Entomol. 75:422-435. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FECUNDITY, ECOLOGICAL DISTRIBUTION, DISTRIBUTION, BEHAVIORAL CHEMICALS, ATTRACTANTS, TAXONOMY, GENETICS Populations of *Dendroctonus frontalis* from Virginia, Texas, Mexico, Honduras and Guatemala were compared regarding morphology, pheromone production, host preference, biology, interbreeding, gallery construction, and attack behavior. Differences in pheromone production, biology and host preference, as well as the failure of some populations to interbreed indicate that the current taxonomic status of *D. frontalis* should be reviewed. It is suggested that some populations be considered as separate species and/or races from *D. frontalis*.

1161. **VITÉ J. P., LÜHL R., HUGHES P. R., RENWICK J. A. A.** 1975. Pine beetles of the genus *Dendroctonus*: Pest populations in Central America. FAO Plant Protection Bull. 23:178-184. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). DISTRIBUTION, TAXONOMY, MORPHOLOGY AND PHYSIOLOGY Bark beetles of the genus *Dendroctonus* occurring in Central America are described. Differences in geographical groups of the same species are discussed in terms of pest surveillance, quarantine regulations and effectiveness of control measures.

1162. **VITÉ J. P., MUDEN H.** 1970. Erste Anwendung synthetischer Populationslockstoffe in der Borkenkaferbekampfung. Allg. Forstzeirschrift 25:615-616. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Dendroctonus pseudotsugae*, *Dendroctonus ponderosae*). AGGREGATION, ATTRACTANTS, REVIEW, BEHAVIORAL CHEMICALS Reviews research at Boyce

Thompson Institute of Plant Research that led to the discovery of frontalin as the principal population aggregation pheromone in *D. frontalis*, *D. brevicomis* and *D. pseudotsugae* and *trans*-verbenol in *D. ponderosae*. Emphasizes the necessity for pheromones to act in combination with host tree volatiles and discusses the manipulation of bark beetle populations using pheromones.

1163. **VITÉ J. P., PITMAN G. B. 1967.** Concepts in research on bark beetle attraction and manipulation. XIV Congr., Int. Union For. Res. Org. 5:683-701. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). BEHAVIORAL CHEMICALS, ATTRACTANTS Briefly reviews the literature on the diversity of bark beetle responses to insect- and host-produced attractants.

1164. **VITÉ J. P., PITMAN G. B. 1968.** Bark beetle aggregation: Effects of feeding on the release of pheromones in *Dendroctonus* and *Ips*. Nature (London.) 218(51 37):169-170. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Dendroctonus ponderosae*, *Ips confusus*). LIFE HISTORY-GENERAL, OVIPOSITION, BEHAVIORAL CHEMICALS, HOST SELECTION, HOST RESISTANCE Differences in production and release of population-aggregating pheromones by bark beetles reflect distinct evolutionary trends in two genera. In *Ips confusus* and related species, chemical messengers provide a means of locating and colonizing scattered and temporary habitats. Continuous ejection of frass from the gallery provides for sustained release of attractants contained in male excrement. Since pheromones are produced as long as the *Ips male* feeds, suitability of host material for colonization is assured. In *Dendroctonus*, pheromones serve primarily as a signal for mass attack of resistant hosts. Production of pheromone continues only as long as the host resists extensive feeding and gallery construction. As soon as extensive feeding and defecation commence, the frass is tightly packed in the gallery. Frass is not as suitable an attractant source for *Dendroctonus* beetles as it is for *Ips*.

1165. **VITÉ J. P., PITMAN G. B., FENTIMAN A. F. JR., KINZER G. W. 1972.** 3-methyl-2-cyclohexen-1-ol isolated from *Dendroctonus*. Naturwissenschaften 10:469. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). BEHAVIORAL CHEMICALS, ATTRACTANTS, HOST SELECTION A pheromone is isolated from *Dendroctonus*.

1166. **VITÉ J. P., RENWICK J. A. A. 1968.** Insect and host factors in the aggregation of the southern pine beetle. Contrib. Boyce Thompson Inst. 24:61-63. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AGGREGATION, BEHAVIORAL CHEMICALS, ATTRACTANTS, HOST SELECTION Adult southern pine beetles, *Dendroctonus frontalis*, responded in the field to olfactometers baited with emergent beetles of the same species, as well as crushed beetles, solvent extracts of crushed beetles, and ground hindguts. Fresh oleoresin, although not attractive *per se*, apparently had an arrestive effect on the beetles. These findings suggest that southern pine beetles produce chemicals responsible for aggregation, while host odors arrest the aggregating populations.

1167. **VITÉ J. P., RENWICK J. A. A. 1971a.** Differential diagnosis and isolation of population attractants. Contrib. Boyce Thompson Inst. 24:323-328. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, MISCELLANEOUS TECHNIQUES A combination of field bioassay and comparative gas chromatographic analyses is described for isolation of bark beetle attractants.

1168. **VITÉ J. P., RENWICK J. A. A. 1971b.** Inhibition of *Dendroctonus frontalis* response to frontalin by isomers of brevicomin. Naturwissenschaften 58:418-419. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*). PREDATOR, PARASITES, ATTRACTANTS, CONTROL-BIOLOGICAL The olfactory response of flying male and female southern pine beetles, *Dendroctonus frontalis*, to the female-produced attractant, frontalin, is inhibited under field conditions by an analogue, *endo*-7-ethyl-5-methyl-6,8-dioxabicyclo [3.2.1] octane, commonly referred to as '*endo*-brevicomin'. Tests in the forest demonstrated that the attraction of *D. frontalis* to traps baited with frontalin and *alpha*-pinene was halted or drastically reduced, but the response of its predator, *Thanasimus dubius*, was unaffected by the addition of the material.

1169. **VITÉ J. P., RENWICK J. A. A. 1976.** Anwendbarkeit von Borkenkaferpheromonen: Konfiguration und Konsequenzen. (Applicability of bark beetle pheromones: Configuration and consequences.). Z. Angew. Entomol. 82:112-116. (COLEOPTERA: SCOLYTIDAE; *Dendroconus* spp., *Ips* spp.). POPULATION DYNAMICS, BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-CHEMICAL, TRAPS AND CAGES Field tests with optically pure isomers of the bark beetle pheromones brevicomin, frontalin and ipsenol indicate biological activity for only one of the possible stereochemical antipodes. Consequently, the formulation of synthetic pheromones for survey or control of bark beetles will have to recognize the chirality-response relationships; synthetic pheromones for attracting beetles to traps or trap trees, may require a higher degree of purity than those intended for beetle dispersion or 'communication disruption.' Pest populations may vary intraspecifically in their pheromones due to stereochemical differences among secondary constituents of their host trees that serve as precursors of pheromone production.

1170. **VITÉ J. P., WILLIAMSON D. L. 1970.** *Thanasimus dubius*: Prey perception. J. Insect Physiol. 16:233-239. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. *Thanasimus dubius*). PREDATOR, PARASITES, DISTRIBUTION, BEHAVIORAL CHEMICALS, ATTRACTANTS *Thanasimus dubius* can locate its prey, *Dendroctonus frontalis*, by responding to pheromones released by the latter. Synthetic frontalin in particular is highly attractive to both sexes of *T. dubius*. This response also facilitates location of mates and suitable breeding sites as well as providing a degree of spatial synchronization.

1171. **WAGNER T. L., FARGO W. S., KELLEY C. L., COULSON R. N., COVER J. D. 1982.** Effects of sequential attack on gallery construction, oviposition and reemergence by *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. 114:491-502. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). OVIPOSITION, EMERGENCE, POPULATION DYNAMICS Following sequential attack, total gallery and eggs decreased with increasing day of attack. Distances between eggs were shortest for pairs attacking second and greatest for pairs attacking last. Inverse relationships of egg-bearing gallery length, oviposition period, and adult residence time were compared with the day of attack.

1172. **WAGNER T. L., FELDMAN R. M., GAGNE J. A., COULSON R. N. 1980.** Models describing gallery construction and oviposition by *Dendroctonus frontalis*. *In*, Modeling Southern Pine Beetle Populations-Symp. Proc. Feb. 20-22., 1980. Asheville, N. C., Stephen F. M., Searcy J. L., Hertel G. D., Eds. USDA For. Serv. Tech. Bull. No. 1630. p. 40-53. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, OVIPOSITION, STATISTICAL METHODS, MODELING Models were developed to describe the combined effects of temperature, beetle density, female size and month of emergence on total gallery construction and eggs per mating pair for *Dendroctonus frontalis*. The cumulative proportion of gallery construction and eggs through time is also described. Due to the interaction of variables influencing gallery construction and oviposition, the effects of single variables could not be described independently. Results suggest different seasonal reproductive strategies by the southern pine beetle. During late winter and early spring, when the contribution of individual females is important, females stay in one host, thus avoiding unpredictable weather conditions. In summer, the reproductive contribution of individual females in single hosts is less important and attacks on new hosts are more important.

1173. **WAGNER T. L., FELDMAN R. M., GAGNE J. A., COVER J. D., COULSON R. N., SCHOOLFIELD R. M. 1981.** Factors affecting gallery construction, oviposition, and reemergence by *Dendroctonus frontalis* in the laboratory. Ann. Entomol. Soc. Am. 74:265-273. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EMERGENCE, MODELING, EGG, OVIPOSITION An examination of different influencing factors (constant temperature, adult density, female size and month of

adult emergence) on the gallery construction and oviposition per mating pairs of *Dendroctonus frontalis* was conducted. Predictive models were developed to describe the combined effects of these factors on total gallery and eggs per pair, and the cumulative proportion of gallery and eggs per pair through time. At 15 degrees Celsius beetles laid more eggs and constructed more galleries. Increasing pairs per squared dm were associated with decreased gallery and eggs per pair. In *D. frontalis*, the effects of density, temperature, size, and type of total gallery and eggs interacted in such a way that it was not possible to independently describe the effects of single variables.

1174. **WAGNER T. L., GAGNE J. A., COVER J. D., COULSON R. N., PULLEY P. E.** 1981. Comparison of gallery construction, oviposition, and reemergence by *Dendroctonus frontalis* females producing first and second broods. Ann. Entomol. Soc. Am. 74:570-575. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EMERGENCE, MODELING, EGG, OVIPOSITION Female *Dendroctonus frontalis* produced more gallery and eggs for their second brood than their first. Initiation of exit galleries into outer bark and reemergence from slabs occurred earlier for females producing their first brood.

1175. **WAGNER T. L., GAGNE J. A., DORAISWAMY P. C., COULSON R. N., BROWN K. W.** 1979. Development time and mortality of *Dendroctonus frontalis* in relation to changes in tree moisture and xylem water potential. Environ. Entomol. 8:1129-1138. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). EGG, LARVAE, HOST RESISTANCE, MISCELLANEOUS TECHNIQUES The effect of southern pine beetle attack on host tree moisture, xylem water potential (as measured by bark, phloem and xylem moisture, and twig xylem water potential), and the effect of changing moisture conditions within the tree on brood survival were examined. Eggs and first instar larvae were not affected, while second and third instar larvae showed reduced developmental rates if phloem moisture was above 170 percent oven dry weight, or if phloem moisture underwent rapid decrease during those stages. Fourth instar larval development was slower in trees with high bark moisture content.

1176. **WALKER L. C.** 1980. Bugs in the pineries. Farmer-Stockman 93:30-31. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, ECONOMICS, IMPACT, REVIEW A popular review of the development and decline of the recent southern pine beetle epidemic includes forest management practices contributing to an increase in southern pine beetle populations, weather relationships contributing to the decline of the outbreak, and comments on preferred control procedures.

1177. **WALTERS E.** 1981. Utilization of Texas southern pine beetle-killed timber for lumber, plywood, and pulpwood. For. Prod. Notes 11:1-2. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, IMPACT Southern pine beetle-killed pines can be used for most products, however grade and recovery can be reduced.

1178. **WALTERS E., WELDON D.** 1982a. Utilization of southern pine beetle killed timber for lumber in East Texas. Tex. For. Serv. Circ. 256. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Summer killed southern pine beetle timber should be removed by 45 days after kill.

1179. **WALTERS E., WELDON D.** 1982b. Veneer recovery from green and beetle killed timber in East Texas. Tex. For. Serv. Circ. 257. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Green and southern pine beetle killed trees were equal in volume, grade and type of veneer produced up to 45 days after kill. After 180 days, veneer recovery dropped 8.8%. Beetle-killed timber should be segregated for drying.

1180. **WALTERS E., WELDON D.** 1982c. Weight loss in southern pine beetle killed timber. Tex. For. Serv. Circ. 258. 4 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WOOD UTILIZATION Sawtimber killed by the southern pine beetle in the summer should be salvaged within 45 days. By 180 days, SPB-killed timber is worth more as pulpwood than as sawlogs.

1181. **WALTERS F. C.** 1979. Estimation of annual timber damages due to southern pine beetle (*Dendroctonus frontalis*, Zimm. [*sic*]) attack. M.S. Thesis, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 118 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, STATISTICAL METHODS, MODELING A model was developed which estimates the potential timber damages associated with southern pine beetle attack. The model is based on benefit-cost analysis comparing the cost and benefits of the control program to the discounted net worth of the timber stand.

1182. **WALTERS F. C., LEUSCHNER W. A.** 1978. Estimating southern pine beetle timber damage. Va. J. Sci. 29:49. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT, ECONOMICS Southern pine beetle timber damage was estimated.

1183. **WALTERS F. C., LEUSCHNER W. A.** 1979. The use of present net worth models in estimating the economic impact of southern pine beetle (*Dendroctonus frontalis* Zimm.) on timber resources. Va. J. Sci. 30:Abstr. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). IMPACT, ECONOMICS The economic impact of the southern pine beetle is estimated.

1184. **WARD J. D., KUCERA D. R., DOWNING G. L.** 1970. Southern and Southeastern States (R-8). USDA For. Serv. For. Insect Conditions in the U. S. 1970. p. 27-29. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp. *Thanasimus dubius*). SURVEY AND DETECTION, REVIEW Extremely low winter temperatures during the winter of 1969-1970 caused extensive mortality to southern pine beetle populations in the southern Appalachians and northern Alabama. However, by midsummer, populations rebounded to epidemic levels in many areas. Black turpentine beetles and *Ips* engraver were very active in areas damaged by hurricane Camille.

1185. **WARD J. G. D., MISTRETTA P. A.** 1977. Southern region (R-8) and Southeastern area. USDA For. Serv. For. Insect and Dis. Conditions in the U. S. 1977. p. 49-51. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips* spp.). SURVEY AND DETECTION, MAPS Southern pine beetle infestations decreased to the lowest intensity in several years except for areas in East Texas and Mississippi. The Texas Forest Service reported 4,505 groups of dying trees in East Texas. Salvage logging and lindane mixed with water were used as control tactics. A distribution map is included.

1186. **WATERS W. E.** 1973. The ecological and socioeconomic components of a management system for the southern pine beetle. Southern pine beetle-A management challenge. Entomol. Soc. Am. Natl. Meet., Dallas, Tex., Nov. 28, 1973. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, CONTROL-GENERAL, ECONOMICS, REVIEW, INTEGRATED PEST MANAGEMENT, IMPACT, STAND CONDITIONS Waters discusses the concepts of pest management and manipulation of the southern pine beetle. The basic components of the forest pest management system, pest population dynamics, forest stand dynamics, treatments and impacts, are integrated in forest pest management decisions. Stressing the idea of technology transfer and getting the information to the user, the final challenge was: Don't let the beetle manage us.

1187. **WATTERSON G. P.** 1979. Effects of verbenone and brevicomin on within-tree populations of *Dendroctonus frontalis* and *Ips avulsus* (Coleoptera: Scolytidae). M.S. Thesis, Tex. A&M Univ., College Station, Tex. 40 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips avulsus*). POPULATION DYNAMICS, EMERGENCE, BEHAVIORAL CHEMICALS, ATTRACTANTS A southern pine beetle infestation was treated with a mixture of *endo*-, exo-brevicomin and verbenone. The chemicals reduced reemerging population density, number of attacking beetles, and gallery density. The emerging population was not significantly reduced. The treatment also resulted in a large increase in *Ips avulsus* population density and gallery density. Trees were attacked and killed by *D. frontalis* and *I. avulsus* despite treatment.

1188. **WATTERSON G. P., PAYNE T. L., RICHERSON J. V.** 1982. The effects of verbenone and brevicomin on the within-tree populations of *Dendroctonus frontalis*. J. Ga. Entomol. Soc. 17:118-126. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, BEHAVIORAL CHEMICALS, ATTRACTANTS Trees adjacent to *Dendroctonus frontalis* infestations were treated just prior to attack with inhibitors in a 1:1 mixture of 85:15 *endo-*, *exo*-brevicomin and verbenone. Treated trees were killed, but reemergent beetle density was reduced by 73%; emergent population density reduced by 63%; and gallery construction reduced by 80%. Attacks by *Ips avulsus* increased 27 times.

1189. **WEBB J. W., FRANKLIN R. T.** 1978. Influence of phloem moisture on brood development of the southern pine beetle (Coleoptera: Scolytidae). Environ. Entomol. 7:405-410. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LARVAE, PUPAE, EMERGENCE, HOST RESISTANCE, MISCELLANEOUS TECHNIQUES Phloem of loblolly and shortleaf pine trees attacked by *Dendroctonus frontalis* exhibited a characteristic drying followed by rehydration. Brood survival was apparently lower in trees with high moisture. In the laboratory, rearing bolts which were waxed to maintain higher phloem moisture had lower beetle survival than unwaxed bolts. High phloem moisture was associated with the formation of long larval mines, instead of feeding chambers, which in turn led to lowered survival. Emergence of the survivors was positively correlated with phloem moisture, suggesting that high moisture was beneficial to larvae and pupae in the outer bark.

1190. **WEIR R. J.** 1975. Cone and seed insects–southern pine beetle: A contrasting impact on forest productivity. Thirteenth South. For. Tree Improvement Conf., June 1975, Raleigh, N. C., p. 182-192. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. HEMIPTERA: COREIDAE; *Leptoglossus corculus*. PENTATOMIDAE; *Tetyra bipunctata*. LEPIDOPTERA: PYRALIDAE; *Dioryctria amatella*. THYSANURA: PHLAEOTHRIPIDAE; *Gnophothrips fuscus*). ECONOMICS, IMPACT Value losses from cone and seed insects are compared with destruction from the southern pine beetle. Losses from cone and seed insects are not as evident as southern pine beetle.

1191. **WEITZMAN S.** 1975. How to control the southern pine beetle. South. Lumberman 230(2849):11-12. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL Present control methods of *Dendroctonus frontalis* are discussed. Improved control techniques are proposed.

1192. **WESTBROOK R. F., HERTEL G. D., SEARCY J. L.** 1981. Wood products from beetle-killed wood. South. Lumberman 241(2999):8-9. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. WOOD UTILIZATION Summarizes the suitability of beetle-killed timber for various wood products. Beetle-killed trees remain suitable for many forest products with some qualifications. Those products discussed include lumber, pulp-paper, plywood, paneling, particleboard, and hardboard.

1193. **WHITE J. D.** 1981. A bioassay for tunneling responses of southern pine beetles to host extractives. J. Ga. Entomol. Soc. 16:484-492. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS Gustatory deterrents and stimuli for *Dendroctonus frontalis* were found in extractives of inner and outer bark of loblolly pine. Relative acceptance of pines for tunneling by southern pine beetle was proposed.

1194. **WHITE J. D., RICHMOND J. A.** 1979. Two olfactometers for observing orientation of the southern pine beetle to host odors. J. Ga. Entomol. Soc. 14:99-106. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, MISCELLANEOUS TECHNIQUES Two olfactometers were constructed to observe the orientation of walking southern pine beetles in an active space during assays. The beetles responded positively to Frontalure-33. Loblolly pine phloem produced greater responses than periderm. High concentration of some host- or insect-associated volatiles may cause repellency.

1195. **WHITE R. A. JR., AGOSIN M., FRANKLIN R. T., WEBB J. W.** 1980. Bark beetle pheromones: Evidence for physiological synthesis mechanisms and their ecological implications. Z. Angew. Entomol. 90:255-274. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). BEHAVIORAL CHEMICALS, REVIEW, MORPHOLOGY AND PHYSIOLOGY An investigation of the mechanisms of terpene metabolism is presented along with a review of past research on this topic. Terpenoid-type bark beetle pheromones are probably cytochrome-P-450-produced metabolites of host terpenes. Terpenoid pheromones are produced by xenobiotic detoxification mechanisms, including cytochrome P-450, epoxide hydrase, and conjugating enzyme systems. Much of the specificity of bark beetle pheromones is a result of differences in protein structure of enzymes among species and sexes.

1196. **WHITE R. A. JR., FRANKLIN R. T.** 1976. Activity of the southern pine beetle in response to temperature. J. Ga. Entomol. 11:370-372. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). FLIGHT, WEATHER RELATIONSHIPS Newly-emerged *Dendroctonus frontalis* adults showed minimal activity at nine degrees Celsius; climbing was observed at 12 degrees Celsius; and flight occurred at 22 degrees Celsius in the laboratory. Flight was restricted at 34-35 degrees Celsius.

1197. **WHITE W. B.** 1976. Site factors and stand conditions associated with southern pine beetle infestations in the Upper Coastal Plains of East Texas. M. For. Thesis, Stephen F. Austin State Univ. Nacogdoches, Tex. 86 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). HOST SELECTION, HOST RESISTANCE, SURVEY AND DETECTION, MODELING, STAND CONDITIONS, HAZARD/RISK RATING Southern pine beetle infestations are most likely to occur in pine stands of above 'average' height, basal area, age, and with declining radial growth. Pine stands found on dry, sandy, upland flats are highly susceptible to bark beetle attack. The need for the development of a stand risk or hazard classification is discussed.

1198. **WILLIAMS I. L.** 1980. Management of southern bark beetles. *In*, For. Pest Manage. Symp., Fla. Sec., Soc. Am. For., June 1980, School of For. Res. and Conservation Res. Rep. 7:64-69. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Ips avulsus, Ips calligraphus, Ips grandicollis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL Summarizes southern pine beetle life history and controls.

1199. **WILLIAMSON D. L.** 1970. A pest management system for the southern pine beetle, *Dendroctonus frontalis* Zimmerman, in East Texas. Ph.D. Diss., Tex. A&M Univ., College Station, Tex. 108 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, BEHAVIORAL CHEMICALS, HOST SELECTION, CONTROL-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL, MODELING, INTEGRATED PEST MANAGEMENT The large chronic outbreaks of southern pine beetle in recent years may be in part a result of the use of persistent, chlorinated hydrocarbon insecticides. The development of a pest management system utilizing synthesized southern pine beetle aggregation pheromone is recommended.

1200. **WILLIAMSON D. L.** 1971a. Management to reduce pine beetle infestations. For. Farmer 30(4):6-7,18. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PREDATOR, PARASITES, BEHAVIORAL CHEMICALS, ATTRACTANTS, CONTROL-BIOLOGICAL, CONTROL-CHEMICAL Widespread use of chlorinated hydrocarbons against the southern pine beetle has failed to have the desired effect. A biological approach to pest control involving the manipulation of the pest's chemical communication system is discussed. A procedure is described using Frontalure-baited trees and cacodylic acid as a control measure.

1201. **WILLIAMSON D. L.** 1971b. Olfactory discernment of prey by *Medetera bistriata* (Diptera: Dolichopodidae). Ann. Entomol. Soc. Am. 64:586-589. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. DIPTERA: DOLICHOPODIDAE; *Medetera bistriata*). PREDATOR, PARASITES, BEHAVIORAL CHEMICALS, ATTRACTANTS, HOST SELECTION Synthetic pheromones of *Dendroctonus frontalis*

were used to determine prey perception of *Medetera bistriata*. *M. bistriata* possesses a mechanism capable of deciphering a bouquet of prey-habitat stimuli. The response behavior of *M. bistriata* enables it to arrive simultaneously with other prey species.

1202. **WILLIAMSON D. L.** 1972. Management system for *Dendroctonus frontalis* populations. Folia. Entomol. Mex. 24:85-86. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). POPULATION DYNAMICS, MODELING, REVIEW The role and effect of insecticide use in East Texas against *Dendroctonus frontalis* are examined. The prolonged epidemic is attributed to the use of insecticides which reduced population levels of natural enemies. Alternative solutions are presented.

1203. **WILLIAMSON D. L., VITÉ J. P.** 1971. Impact of insecticidal control on the southern pine beetle population in East Texas. J. Econ. Entomol. 64:1440-1444. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CLERIDAE; *Thanasimus dubius*. DIPTERA: DOLICHOPODIDAE; *Medetera bistriata*. *Heydenia unica*. *Roptrocerus eccoptogastri*). POPULATION DYNAMICS, ATTRACTANTS, CONTROL-GENERAL, CONTROL-CHEMICAL High concentrations of insecticides coupled with the use of an oil-based carrier (i.e. benzene hexachloride plus diesel oil) may lead to the creation of chronic pest problems. Chemical treatment for the southern pine beetle inadvertently becomes more detrimental to beneficial insects than to target insects.

1204. **WILLIS N. P., HODGSON E.** 1970. Phospholipids and their constituent fatty acids in two populations of *Dendroctonus frontalis* (Coleoptera: Scolytidae). Ann. Entomol. Soc. Am. 63:1585-1591. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). MISCELLANEOUS TECHNIQUES, MORPHOLOGY AND PHYSIOLOGY The neutral lipids and the phospholipids and their fatty acids from two populations of *Dendroctonus frontalis* are compared. The principal phospholipid base is choline. The amount of plasmalogen present in the lipids is much larger than that usually found in insects or in other animals. The fatty acids in all lipid categories are primarily 16- and 18-carbon acids.

1205. **WILLISTON H. L., ROGERS T. J., ANDERSON R. L.** 1980. Forest management practices to prevent insect and disease damage to southern pine. USDA For. Serv. Southeast. Area For. Rep. SA-FR9. 9 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*. CURCULIONIDAE; *Hylobius pales*, *Pachylobius picivorus*. SCARABAIDAE; *Phyllophaga* spp.). CONTROL-GENERAL, CONTROL-CULTURAL Recommended practices for controlling the southern pine beetle include: 1) maintaining correct stand density, 2) salvaging damaged pines, 3) harvesting at the proper rotation age, and 4) matching trees to the site.

1206. **WISEMAN T.** 1978. Beat pine beetle—harvest quickly. Ala. For. Prod. 21(6):25. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-CULTURAL Control of southern pine beetle by logging and removing beetle-killed trees is discussed.

1207. **WISEMAN T.** 1979. Homeowner: Is your shade tree's bark tougher than the pine beetle's bite? For. and People 29:30-31. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, REVIEW Characteristics of southern pine beetle attack, as well as susceptible pine trees, are discussed.

1208. **WISEMAN T.** 1979. Lawn trees are often targets of southern pine beetle attack. For. Farmer 38(7):11,14. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL Characteristics of susceptible pine trees are discussed, as well as southern pine beetle attack characteristics.

1209. **WOOD D. L.** 1970. Pheromones of bark beetles. *In*, Control of Insect Behavior by Natural Products. Acad. Press, Inc. p. 301-316. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*, *Ips confusus*). BEHAVIORAL CHEMICALS, ATTRACTANTS, REVIEW Reviews pheromones of bark beetles emphasizing *Dendroctonus brevicomis* and *Ips confusus*; brief notes on *D. frontalis*.

1210. **WOOD D. L.** 1977. Manipulation of forest insect pests. *In*, Chemical Control of Insect Behavior: Theory and Application. H. H. Shorey and J. J. McKelvey, Jr., Eds. John Wiley and Sons, Inc., New York. p. 369-384. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus ponderosae*, *Dendroctonus pseudotsugae*, *Dendroctonus rufipennis*, *Dendroctonus brevicomis*, *Ips paraconfusus*, *Gnathotrichus sulcatus*, *Scolytus multistriatus*). BEHAVIORAL CHEMICALS, ATTRACTANTS, HOST SELECTION, HOST RESISTANCE, INTEGRATED PEST MANAGEMENT Loblolly pines are killed with cacodylic acid, then baited with frontalure; the pines are then attacked by *Dendroctonus frontalis* and their progeny dies in the poisoned trees.

1211. **WOOD D. L.** 1979. Development of behavior modifying chemicals for use in forest pest management in the U.S.A. Proc. Advanced Res. Inst. on Chem. Ecol.: Odour Communications in Animals p. 261-279. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Dendroctonus brevicomis*). BEHAVIORAL CHEMICALS, MISCELLANEOUS TECHNIQUES Information concerning the registration of behavior-modifying chemicals with regulatory agencies is discussed. These chemicals should be considered separately from insecticides when applying them to EPA guidelines. Potential human and environmental hazards from these chemicals may exist. Very little information exists on the effect of these chemicals on the generation of insects following the treated group.

1212. **WOOD D. L., SILVERSTEIN R. M.** 1970. Bark beetle pheromones. Nature 225(5232):557-558. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ATTRACTANTS The authors dispute the validity of the conclusions reached by Kinzer et al. regarding pheromones (naming, function, type) and oleoresin in *Dendroctonus frontalis*.

1213. **WOOD D. L.** 1982. The role of pheromones, kairomones, and allomones in the host selection of bark beetles. Annu. Rev. Entomol. 27:411-446. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*, *Ips avulsus*, *Ips calligraphus*, *Ips grandicollis*). ATTRACTANTS, HOST SELECTION, BEHAVIORAL CHEMICALS, FLIGHT The interspecific interaction of *Dendroctonus frontalis* and the three *Ips* species are discussed in the context of allomones in the colonization of pines by bark beetles.

1214. **WOOD J.** 1977. "Control" of the southern pine beetle. Tex. For. News 56:14-16. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL Control tactics for the southern pine beetle are discussed.

1215. **WOOD J. R.** 1979. Southern pine beetle control for large industrial forest lands. *In*, Evaluating Control Tactics for the South. Pine Beetle-Symp. Proc. Jan 30-Feb. 1, 1979. Many, La., Coster J. E., Searcy J. L., Eds. USDA For. Serv. Tech. Bull. No. 1613. p. 8-10. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). CONTROL-GENERAL, ECONOMICS, IMPACT Income cost effects of the southern pine beetle on Kirby forest lands, along with the setting of performance targets controlled by the profit center have allowed Kirby to control southern pine beetle losses.

1216. **WOOD S. L.** 1963. A revision of the bark beetle genus *Dendroctonus* Erickson (Coleoptera: Scolytidae). Great Basin Nat. 23(1/2):1-116. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus* spp.). LIFE HISTORY-GENERAL, DISTRIBUTION, HOST SELECTION, REVIEW, TAXONOMY, MORPHOLOGY AND PHYSIOLOGY *Dendroctonus mexicanus* was placed in synonymy with *D. frontalis*. In 1974 (S. L. Wood), it was removed from synonymy.

1217. **WOOD S. L.** 1974. New synonymy and records of American bark beetles (Coleoptera: Scolytidae). Great Basin Nat. 34:277-290. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus vitei*, *Dendroctonus mexicanus*, *Dendroctonus valens*). DISTRIBUTION, TAXONOMY *Dendroctonus mexicanus* Hopkins and *D. vitei* n. sp. are discussed and the taxonomy and type material of *D. vitei* are presented.

1218. **WOOD S. L.** 1982. The bark and ambrosia beetles of North and

Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Naturalist Memoirs 6:1-1359. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans, Dendroctonus vitei, Dendroctonus mexicanus, Ips avulsus, Ips calligraphus, Ips grandicollis*). TAXONOMY The taxonomy of *Dendroctonus frontalis* Zimmermann is presented.

1219. **WOODARD J. R., BIESBROCK J. A.** 1976. Use of high altitude aerial photography to study southern pine beetle infestations. Bull. Ga. Acad. Sci. (Abst.) 34:59. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, MISCELLANEOUS TECHNIQUES Application of high altitude color-infrared imagery showed that 80% of 149 beetle-infested areas discernible by infrared were on ridgetops; the remainder were on side-slopes of a southern or southwestern aspect.

1220. **WOODRING J. P., MOSER J. C.** 1970. Six new species of anoetid mites associated with North American Scolytidae. Can. Entomol. 102:1237-1257. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips* spp.). PREDATOR, PARASITES, TAXONOMY, MITES Five new species of *Anoetus* and one of *Bonomoia* associated with bark beetles in North America are described. Detailed taxonomic diagrams are supplied. Also included is an annotated list of bark-beetle-associated anoetids with new nomenclature.

1221. **WOODRING J. P., MOSER J. C.** 1975. Description of *Histiostoma conjuncta* (new comb.) (Acari: Anoetidae), an associate of Central American bark beetles. Proc. Entomol. Soc. Wash. 77:83-86. (COLEOPTERA: SCOLYTIDAE; ACARI: ANOETIDAE; *Histiostoma conjuncta*). PREDATOR, PARASITES, DISTRIBUTION, REVIEW, MITES The adult male and female and tritonymph of *Histiostoma conjuncta* are described. This species is known to be associated with various pine bark beetles, including *Dendroctonus frontalis*.

1222. **WOOTTEN J. F.** 1963. Southern and Southeastern States. USDA For. Serv. For. Insect Conditions in the U.S. 1963. p. 28. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). SURVEY AND DETECTION, REVIEW Southern pine beetle populations declined to a relatively low level in 1963 in the southern and southeastern States. The decrease was probably caused in part by low winter temperatures.

1223. **WYMAN L.** 1924. Bark-beetle epidemics and rainfall deficiency. USDA For. Serv. Bull. 8(40):2-3. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). WEATHER RELATIONSHIPS Southern pine beetle often occurred after droughts.

1224. **YATES H. O. III.** 1972a. Identifying three pine bark beetles (Coleoptera: Scolytidae) likely to be found in northeastern Nicaragua. FAO Plant Prot. Bull. 20:101-104. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips calligraphus Ips cribicollis*). ADULT, DISTRIBUTION Three possible pine bark beetles (*Dendroctonus frontalis, Ips cribicollis*, and *Ips calligraphus*) of northeastern Nicaragua are discussed. Taxonomic characteristics and keys are provided for identification.

1225. **YATES H. O. III.** 1972b. Bark beetles attacking Caribbean pine in northeastern Nicaragua. FAO Plant Protect. Bull. 20:25-27. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Ips cribicollis, Ips calligraphus*). SURVEY AND DETECTION, IMPACT *Dendroctonus frontalis* attacked more than two million hectares of pine forests in Honduras and crossed the border into Nicaragua.

1226. **YOUNAN E. G.** 1979. Part I. Relative effectiveness of five trap designs for insects attacking severed shortleaf, Virginia, and loblolly pines. Part II. Sequence of arrival of insects associated with bark beetles at severed shortleaf, Virginia, and loblolly pines. Ph. D. Diss., North Carolina State Univ., Raleigh, N. C. 119 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). PARASITES, PREDATOR, TRAPS AND CAGES. Southern pine beetle parasites were collected on severed pines.

1227. **YOUNG R. L.** 1977. Estimation of the economic impact of southern pine beetle on reservoir recreation. M. S. Thesis, Va. Polytech. Inst. & State Univ., Blacksburg, Va. 118 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ECONOMICS, MODELING, AESTHETICS When computing benefits produced by a southern pine beetle control program, potential recreation benefits should be estimated for inclusion in total program benefits. A model was developed for estimating recreation variables such as on-site activities, scenery, cost of recreating, substitute recreation sites, and recreation demand.

1228. **YOUNG R. L., LEUSCHNER W. A.** 1977. A methodology for estimating the economic impact of southern pine beetle on reservoir recreation. Va. J. Sci. 28:56. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). AESTHETICS, IMPACT Economic impact of southern pine beetle on recreation areas should include variables relating to recreation demands and substitute demands.

1229. **YU C., TSAO C. H.** 1967. Gallery construction and sexual behavior in the southern pine beetle, *Dendroctonus frontalis* Zimm. (Coleoptera: Scolytidae). J. Ga. Entomol. Soc. 2:95-98. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). ADULT, OVIPOSITION, DISTRIBUTION, EMERGENCE, BEHAVIORAL CHEMICALS, MISCELLANEOUS TECHNIQUES Galleries made by males and females together in bark sandwiches were longer than the combined lengths of galleries made by males or females alone. Parent beetles started to emerge from the bolts on the tenth day; on the eighteenth day 80% of the females and 65% of the males had emerged. Both males and females were found to mate more than once; each mating lasted an average of 133 seconds.

1230. **ZIMMERMAN A. H.** 1948. Pine tree killers. Progressive Farmer 63(8):19. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-GENERAL Zimmerman summarizes the life history and controls for the southern pine beetle. Controls include a mixture of kerosene and orthodichlorobenzene.

1231. **ZIMMERMAN A. H.** 1948. The southern pine beetle in the Tennessee Valley. Tenn. Valley Auth. Div. For. Relations. 6 p. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis*). LIFE HISTORY-GENERAL, CONTROL-BIOLOGICAL, CONTROL-CULTURAL Describes life cycle and stages of *Dendroctonus frontalis*. Steps for control included cutting all dead-topped pines and stripping the bark; resurveying the area at two-week intervals during warm, dry weather; and cutting damaged pines having beetle brood in them. Chemical controls may be used if the bark is too hard to peel. Attacks may be prevented by cutting weakened, damaged trees, by keeping healthy, vigorous pines and protecting woodpeckers and song birds.

1232. **ZIMMERMANN C.** 1868. Synopsis of the Scolytidae of America north of Mexico. Trans. Am. Entomol. Soc. 2:141-149. (COLEOPTERA: SCOLYTIDAE; *Dendroctonus frontalis, Dendroctonus terebrans*). TAXONOMY Describes adults of *Dendroctonus frontalis*.

INDEXES

AUTHOR

TAXONOMY

KEYS

ACKNOWLEDGMENTS

We wish to thank Dr. Jack E. Coster, Dr. Thomas L. Payne and Dr. Robert C. Thatcher for contributions to early versions of this bibliography. The following individuals assisted with library research, editing, data entries, interlibrary loan material and filing of articles: B. J. Bentz, K. D. Cole, M. A. Federman, J. N. Lenahan, C. L. Mask, C. Plume, A. Schmidt. M. A. Shupe, M. C. Vanlandingham, J. A. Wilder, S. R. Willis, K. H. Wilson, and J. J. Wunderlich, SFASU, and R. Fisher and J. Delorme, Texas A and M University.

Special thanks to Mr. Don Richter, Research Librarian, and Liz Logan, Interlibrary Loan Supervisor, SFASU Steen Library, for their patience and assistance in acquiring interlibrary loan material. Dr. John L. Foltz, University of Florida, provided an advance copy of a FAMULUS bibliography of *Ips* and the black turpentine beetle, *Dendroctonus terebrans*. Morris Lang, Computer Center, SFASU, assisted in data transmission of the FAMULUS file for publication.

This project was supported by funds from the Integrated Pest Management—Southern Pine Bark Beetles Program, administered by the USDA Forest Service, Pineville, Louisiana (Agreement # 19-18-13), and McIntire-Stennis funds administered by the School of Forestry, Center for Applied Studies, SFASU.

STEPHEN F. AUSTIN
STATE UNIVERSITY
NACOGDOCHES, TEXAS